Does Corporate Ownership Impact the Probability of Informed Trading?

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Abstract

As individuals or families hold a substantial share of a firm at the cost of less diversified portfolio, they specialize their portfolio and have better inside information. Does the market marker react to this fact and maintain higher level of asymmetric information cost for such family-controlled firms? We analyze the bid-ask spread and the probability of informed trading (PIN) of Canadian-based publicly traded firms cross-listed with NYSE/AMEX to test this notion. We find that although the market maker maintains higher average spread, he does not form higher PIN for family-controlled firms when the entire day is considered as an event period.

The assumption of constant arrival rates of informed and uninformed traders during the day in Easley et al (1996b) is rejected in the two periods per day analysis. In addition, the notion of information event occurrence prior to the day in Easley et al (1996b) is consistently rejected as higher (non-statistically) probability of information events is found in the afternoon (second session) in the two (three) periods per day analyses, respectively. Based on these findings, we have serious doubts about any existing findings (including ours) of PIN based on one period per day. As such, we consider the possibility of several periods per day.

Though it remains an empirical question to choose how many periods should be considered, we find our results using two and three periods per day to be very interesting. We consistently reject the hypothesis that the PIN is higher for family-controlled firms. Since the market maker does not need to maintain high spread for firms with very high number of uninformed traders and very low number of informed traders, we do not perceive our findings to be either surprising or contradictory to the present literature. By developing a different formulation of PIN, we also show that this is empirically less than that developed by Easley et al (1996b).

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Chapter 1

Introduction

In this study, we investigate the level of asymmetric information and its impact on the probability of informed trading (PIN) of Canadian-based, publicly traded family-controlled firms cross-listed with the U.S. exchanges and we compare this with a sample of widely-held cross-listed firms. More specifically, we estimate different parameters of the likelihood function of Easley et al (1996b) to calculate PINs for both of our samples and analyze whether the PIN of family-controlled firms is higher than that of widely-held firms. We define family-controlled firms to be firms in which individuals, families, or any non-financial groups (excluding pension funds, mutual funds, investment funds, etc.) have more than a 10% voting right.[1]

Several existing studies in market microstructure, e.g. Copeland and Galai (1983), Golsten and Milgrom (1985), Easley and O'Hara (1987), Easley et al (1996a, 1996b and 1997), have examined the impact of information asymmetry on stock prices. Informed traders have special information about the stock value and therefore, always expect to gain by trading with the market maker. A market maker presumably cannot detect informed traders, and therefore maintains a spread to recoup losses from uninformed traders. Easley et al (1996b) present a mechanism (called PIN) to estimate the probability of informed trading. They document a higher PIN for less actively traded stocks and argue that the value of these face more asymmetric information. Chiang and Venkatesh (1988) note a greater level of information asymmetry for smaller firms. Easley et al (2002) reach a similar conclusion by using the PIN variable. If PIN is a good statistic to

[1] This criterion follows La Porta et al (1999). They define control at 10% because it is a significant threshold of votes to influence decision making.

estimate the probability of informed trading, it should provide different values for samples containing significantly different levels of information asymmetry.

Several studies in corporate finance (e.g. Seyhun (1986), Howe and Lin (1990), Chiang and Venkatesh (1988), and Fidrmuc et al (2006)) suggest that abnormal profits are made by insiders. Since insiders profit at the cost of the market maker, studies like Seyhun (1986) and Howe and Lin (1990) also report a positive relationship between the bid-ask spread and the market maker's expected losses to insiders. Furthermore, Fidrmuc et al (2006) recommend considering a narrower definition of insiders to get more pronounced abnormal returns in the U.S. context. This implies that some insiders possess more *inside* information than others.

Individuals, families, or a group of people may act as insiders by controlling significant shareholdings. In a model presented by Burkart et al (2002), a founder of a firm is willing to hold a substantial shareholding if he expects the potential amenities (non-pecuniary benefits) to be very large. This may apply to a large proportion of Canadian firms. Morck et al (1998), La Porta et al (1999), and our sample of cross-listed public companies over 2004-05 report a large number of family-controlled firms. Morck et al (1998) also elaborately document the intensity of influence that several controlling individuals or families have on firms' management in Canada. Since controlling groups related to the management have access to inside information, market markers may face substantial losses when trading with them. In this study, we hypothesize that market makers quote higher bid-ask spread for family-controlled firms to recoup such losses. As a higher level of information asymmetry is suspected in family-controlled firms, we also suspect a higher probability of informed trading for these firms, which should lead to a higher PIN estimate.

This study is important and innovative for several reasons. First, although several studies have documented abnormal profits by insiders, further research is definitely warranted with a narrower definition of insiders. We consider family-controlled versus widely-held firms to serve this purpose. We test whether the bid-ask spread and PIN are higher for family-controlled firms. Second, we attempt to answer a corporate finance problem from a market microstructure point of view. To the best of our knowledge, no existing study has tested the probability of informed trading in this context. Third, in addition to the conventional approach of taking a trading day as an event period, we segregate each trading day into multiple periods. Easley et al (1997) note "the assumption that information event occurs only prior to the start of a trading day is clearly an abstraction".[2] On the other hand, it is an empirical fact that trading volume is higher during the first and last couple of hours of the day (e.g., Lee and Ready (1991) observe higher trading volume before 11:00 am and after 2:30 pm of a day). Do different trading frequencies (and trader arrival rates) within a day imply different event periods? Do the assumptions of constant arrival rates of both informed and uninformed traders throughout the day in Easley et al (1996a, 1996b, 1997) hold? We try to address these questions empirically in this study. Fourth, we derive a different formulation to calculate the probability of informed trading, which we dub modified PIN. In this paper, we also attempt to empirically investigate whether the PIN calculation of Easley et al (1996b) is significantly different from our modified PIN.

[2] See page 810 of Easley et al (1997).

Our most important empirical result, which may be the most interesting one, is that the market maker does not form significantly different PINs for family-controlled (PIN_{FC}) and widely-held firms (PIN_{WH}) considering a whole trading day as an event period. However, he does so for the morning session (before 1:00 pm) in the two-period analysis. Though the average PIN_{FC} is found to be higher than the average PIN_{WH} in the one-period and three-periods -per-day analysis, we find an opposite scenario in the two-periods-per-day analysis. Based on the evidence, we conclusively report that the market maker does not form significantly higher PIN for family-controlled firms. We also find that PIN for family-controlled firms for the morning session differs from that of the afternoon session (after 1:00 pm). We perceive our findings consistent with existing literature as the market maker does not need to maintain a high spread for firms with a high number of uninformed traders and a low number of informed traders. In addition, informed traders may not trade on their information (e.g. due to strict state regulation). Although various studies in corporate finance report abnormal returns by insiders, we do not know what proportion of such insiders actually trade. Furthermore, we do not investigate in this study whether controlling individuals/families are related to the management. The level of information asymmetry of a firm is expected to be low if the controlling individuals/families are found to be unrelated to the management [see Fidrmuc et al (2006)]. This fact should result in lower PIN.

Our findings provide evidence in favour of different arrival rates of informed and uninformed traders within the trading day. Therefore, we reject the assumption of constant arrival rates of informed and uninformed traders in the Poisson processes of the likelihood function developed by Easley et al (1996b). Furthermore, the assumption that information events occur only at the beginning of the day is consistently rejected for our sample firms by finding a higher probability of information events for multiple event periods per day.

These results cast serious doubts on the existing findings that involve PIN being estimated using a full trading day as an event period. Since we reach different conclusions by considering different periods per trading day, i.e. statistically similar PINs for family-controlled and widely-held firms in the three-periods-per-day analysis and significantly lower PIN for family-controlled firms in the two-periods-per-day analysis, we recommend further research to reconcile this issue, as it is critical to estimate PIN. Finally, we find that the probability of information events is significantly greater than zero and less than 1, which causes the PIN of Easley et al (1996b) to be significantly different from the modified one, as we will show in Section 4.3.

This study is organized as follows. In the next chapter, we set up a foundation to justify the current study. After considerable discussion of related papers, we develop several hypotheses. Chapter 3 deals with sample construction and methodology. Besides explaining the PIN of Easley et al (1996b), we also develop our modified PIN. In Chapter 4, we present our findings on firms cross-listed with NYSE and AMEX. We use several parametric and non-parametric test statistics to test the hypotheses developed in Chapter 2. It should be noted that we perform our analysis of family-controlled and widely-held firms by considering unconstrained likelihood estimation function. However, we perform a robustness check using constrained likelihood estimation in Chapter 4 to further strengthen our findings. In addition, we present findings on NASDAQ listed firms. In

Chapter 5, we summarize our findings and outline some potential research topics related to this study.

Chapter 2

Literature Review and Hypotheses

We discuss several papers related to this study in the first section of this chapter. To ensure a clear understanding of the existing literature and its relation to the current study, we begin by relating information asymmetry to spread. Next, we present existing findings on the relationship between insider trading and spread. Then we justify using family-controlled firms as those with greater information asymmetry. Since we analyze information asymmetric cost through the probability of informed trading in the current study, we provide a detail explanation of relevant information-based trading models and the PIN.

Based on the literature review, we develop several hypotheses in Section 2 of this chapter. We also outline our expectations on those hypotheses.

2.1 Literature Review

2.1.1 Information Asymmetry and Spread

In economic theory, market participants are assumed to submit their demand and supply schedules to set up the equilibrium price in a Walrasian auction where the auctioneer ensures perfect competition. Perfect competition refers to the presence of perfect information and no transaction costs. This concept of equilibrium price in a Walrasian auction setup does not reflect the reality of stock markets around the world. In addition to imperfect information and transaction costs, there is also the cost of immediacy. A market maker is significantly different from a Walrasian auctioneer and therefore, faces a different problem.

In a world with asymmetric information, the decision making processes of market participants become more complicated. Studies of the 2001 Nobel Laureates Akerlof (1970), Spence (1973), and Stiglitz (1980, with Grossman) provide a basis for research on information asymmetry. Akerlof (1970) demonstrates the impact of information asymmetry in a market where bad quality products drive out good quality products. Spence (1973) shows how potential employees signal employers about their quality in a market with asymmetric information. He illustrates that both high and low quality employees are better off in a market where signalling is possible. Grossman and Stiglitz (1980) directly question the efficient market hypothesis in the presence of asymmetric information. They argue that price cannot reflect all available information, since if it could, there would be no incentive for informed traders to acquire costly information.

Market microstructure is the field that analyzes the market maker's decision problem in the presence of asymmetric information costs (adverse selection cost), and cost of immediacy and trading. In particular, it attempts to investigate how the market maker incorporates some of these costs into stock prices. Considering different types of costs, researchers in this area have introduced two distinct models: inventory-based models and information-based models. Both models obtain a positive bid-ask spread after considering relevant factors. However, the analysis of one model requires enough assumptions to limit the influence of another. Despite this apparent limitation, the information-based model is widely accepted for its appealing theoretical robustness and empirical findings.

In inventory-based models [see, for example, Garman (1976)], the market maker acts as a dealer and wants to hold an optimal level of inventory of stock and cash. Buy and sell orders arrive to the market, and since these orders do not synchronize, the dealer has to shift from his preferred level of holdings. If the market maker runs out of either stock or cash, he fails. To avoid this failure problem, he maintains a spread by buying at a lower bid price and selling at a higher ask price. However if the dealer has a preferred level of holding, then inventory will be mean-reverting and this may induce serial dependence in prices, a phenomenon that complicates the inventory effects.[3]

The information-based trading models take both the cost of immediacy and asymmetric information into account. Bagehot (1971) is mainly credited for instigating research in asymmetric information. He notes that market gains and trading gains carry different meanings. Uninformed traders may lose even when the market gains; informed traders may establish specific trading mechanisms to gain at the expense of uninformed traders. Based on this idea, Copeland and Galai (1983) consider a market with informed traders in a two-period framework. In this framework, uninformed traders transact for exogenous reasons[4] while informed traders' trading interest is obvious. Since the dealer always loses to informed traders, he maintains a spread between bid and ask prices to recoup losses from uninformed traders. In their two-period model, one round of trading discloses all the underlying asymmetric information and there is no need for the market maker to learn from the previous trades.

Glosten and Milgrom (1985) consider a sequential trading model, which allows the market maker to learn from previous trades. In their market setup, the specialist quotes bid and ask prices, traders arrive to the specialist's post one by one (each having

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[3] See O'Hara (1995).

[4] Milgrom and Stockey (1982) note that since uninformed traders always loss to informed traders, it is optimal for them not to be involved in speculation-based trading. Therefore, uninformed traders only trade for non-speculation reasons, e.g. liquidity reasons.

the option to trade one unit of stock or leave) and the specialist is free to update his bid and ask prices after each round of trading. An important assumption is that the specialist knows the probabilistic structure of the arrival process and therefore, knows the probability of trading with an informed trader. Like uninformed traders, informed traders have access to past transaction prices (H_t) and the bid (B_t) and ask (A_t) prices at time t. In addition, informed traders have special information (J_t) about the stock price. Stock price has an eventual end-of-day (or end-of-period) price, which is denoted as a random variable V. In this scenario, the trader will trade if any of the following conditions are satisfied.

$$\begin{array}{c} Buy\ if\ Z_t > A_t \\ Sell\ if\ Z_t < B_t \end{array},$$

where $Z_t = I_t E[V|H_t, A_t, B_t] + (1 - I_t)E[V|H_t, J_t, A_t, B_t]$. $I_t = 1$ if trader is uninformed and 0 otherwise. In other word, Z_t is the investor's perception of the assets fair value.

Given this behaviour of the traders, a competitive market maker with S_t information sets his bid and ask prices in the following fashion:

$$\begin{aligned} A_t &= E[V|S_t, Z_t > A_t] = E[V|S_t, Buy] \\ B_t &= E[V|S_t, Z_t < B_t] = E[V|S_t, Sell] \end{aligned}.$$

The main contribution of Glosten and Milgrom (1985) is clear from these prices: the specialist forms his bid (ask) price by conditioning on the next trade being seller (buyer) initiated. The market maker essentially learns through a Bayesian process. He believes that the trade sequences can reveal underlying information and therefore, adjusts prices accordingly. The authors show that the specialist's expected value and informed traders' perceived value of the stock eventually converge. Another important finding of this study is that the market collapses if the insiders are too numerous – a situation very similar to that in Akerloff (1970). The market maker will set so high an ask price and so low a bid price that even the informed traders would incur a loss if they traded.

Both Copeland and Galai (1983) and Glosten and Milgrom (1985) consider competitive informed traders who do not trade strategically. Kyle (1985) weakens this by assuming that the informed traders know the exact distribution of the uninformed traders' order flow and may use this information to camouflage their trades. In Kyle's (1985) model, the market marker sets the price by observing aggregate order flow of informed and uninformed traders. In doing so, he takes the market depth ($1/\lambda$) into consideration. He aggregates all the order flow and clears all trades at a *single* price in a batch-trading setup. Since our objective is to empirically test whether information asymmetry induces a spread, we do not consider Kyle's (1985) model in detail.

2.1.2 Insider Trading and Spread

We begin by relating information asymmetry to spread. As discussed, one of the most important findings of Copeland and Galai (1983) and Glosten and Milgrom (1985) is that information asymmetry alone is sufficient to induce a spread. Since the market maker widens the bid-ask spread in anticipation of informed trading, it is expected in these studies that the informed traders' (or insiders') profits will be abnormally large (with these profits arising indirectly through losses to uninformed traders).

Seyhun (1986) is the first to empirically analyze and support the hypothesis of Copeland and Galai (1983), and Glosten and Milgrom (1985) that a positive relationship exists between the insiders' abnormal profits and the bid-ask spreads. Seyhun (1986) examines approximately 60,000 insider transactions of NYSE and AMEX, and finds that insiders can predict the future movements of stock prices and make abnormal profits. In particular, insiders purchase stocks before making public any favourable information and sell after the release of such information. Seyhun (1986) is also the first to analyze the sources of insiders' superior predictive ability. It appears from his analysis that insiders more-closely associated with the everyday decision-making process, e.g. officer-directors and chairmen of the board of directors,[5] trade on more valuable information than the other insiders. Howe and Lin (1990) conduct an analogous research on the OTC/NASDAQ market and find very similar results to those of Seyhun (1986). They find all insiders except large unaffiliated shareholders to be successful predictors of future stock price movements.

Why is the large shareholders' predictive ability not in line with other insiders? Demsetz (1986) reports that families and individuals, as corporate insiders, own a significant proportion of a firm at the expense of having a less diversified portfolio. In doing so, they specialize their portfolio. On the other hand, institutional investors like pension funds may also hold a substantial portion of a firm's stock. These institutions also have an incentive to acquire information due to the economy of scale effect. However, Demsetz (1986) states that for "legal and fiduciary constraints", institutional investors do not specialize their portfolios. Chiang and Venkatesh (1988) analyze this question empirically from the viewpoint of dealers/specialists. They find that dealers/specialists perceive corporate insiders as a major factor in determining the information trading cost (or adverse selection cost). However, institutional holdings are not found to influence the dealer's/specialist's information trading cost in the presence of holding cost variables. We should note that the large shareholders in Seyhun (1986) and

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[5] Directors, officers, chairmen of the board, officer-directors and large shareholders are five different types of insiders in Seyhun (1986)

Howe and Lin (1990) are not related to the management of the firms. In addition, large shareholders, such as investment advisors and other financial institutions, cannot be insiders [see footnote 33 of Fidrmuc et al (2006)]. Therefore, large shareholders of those studies may be best termed as institutional investors.

Admati et al (1994) theoretically prove that monitoring activism by large shareholders is consistent with equilibrium even with the “free-rider” problem. A “free-rider” problem occurs as small shareholders benefit from the monitoring activities of large shareholders without *directly* paying for the service. Many empirical studies analyze the effect of monitoring activities on information asymmetry and thereby, spread. For example, Jiang and Kim (2005) report significant negative relationship among institutional ownership, analyst following, and spread. They analyze U.S. and non-U.S. stocks (ADRs), and document that higher spreads on non-U.S. stocks are due to less institutional ownership and a lower number of analysts following those stocks. Our explanation to this is that institutional investors, as non-insiders, may analyze public information only and thus make the market more efficient in a semi-strong sense.

A recent study by Fidrmuc et al (2006) analyzes the trading of a specific type of insiders within the context of the U.K. market. Their results not only confirm the existing findings that insiders are better informed and make abnormal profits but also explain why insiders are better informed. They analyze the trading of the U.K. directors, and find that the U.K. directors’ abnormal returns are much higher than those of the U.S. insiders. Besides accounting for the more stringent and faster reporting regulation of the U.K., they claim that the difference in the definition of insiders in these two countries may induce different abnormal returns. Since the U.S. has a broader definition of insiders and since most of the U.S. papers investigate the effects of aggregate insider trading, the lower abnormal returns found in the U.S. studies are not surprising. Another interesting aspect of this study is that it takes into account the firm's ownership structure when considering directors' transactions in the presence of outside blockholders, i.e. institutional investors, corporations and families/individuals. By regressing directors' abnormal returns on different dummy variables of blockholders, they find corporations and families/individuals have a negative and institutional investors have a positive relationship with the directors' abnormal profits. However, only the coefficient of corporation is found to be significant at 1% level. They conclude that corporations better serve to monitor the management to ensure value maximization and mitigate problems of information asymmetry than institutional investors. This finding confirms the idea of Demsetz (1986) that concentrated ownership with less diversified portfolio encourages monitoring activities.

Monitoring activities, and therefore information asymmetry, may also be a function of the perceived company performance. Bradley and Seyhun (1997) analyze insider trading of firms filing bankruptcy petitions. They find significant sales by insiders before filing dates. Although insiders may minimize their losses by selling before the public announcement of such news, such actions essentially increase the risk to outside atomistic shareholders.

Bid-ask spread may also be influenced by the firm size effect of Banz (1981). Chiang and Venkatesh (1988) note that a smaller firm usually has a smaller number of insiders who are able to pose a greater threat to and induce a greater adverse selection problem for the dealer/specialist. Several studies like Seyhun (1986), Howe and Lin

(1990), and Rozeff and Zaman (1988) find abnormal profits of insider trading even after considering for firm size effect and trading costs. By considering the transaction costs effectively, these studies also put an end to the long-standing controversy that outsiders can make abnormal profits by mimicking insiders' trading.

In a nutshell, the existing literature documents abnormal profits by insiders and reports a positive relationship between insiders' abnormal returns and spreads. This makes it evident that the market maker observes or infers such trading and adjusts his prices accordingly.

2.1.3 Family-Controlled Firms and Insider Trading

The existing literature inarguably reports that insider trading introduces bid-ask spreads. Different studies have considered different types of insiders. Seyhun (1986) and Howe and Lin (1990) consider officers, directors, officer-directors, chairmen of the board and large shareholders as insiders. Though any types of informed traders will induce a spread in their model, Glosten and Milgrom (1985) refer to the "informed traders as insiders". Whatever may be their intention, this definition of insiders obviously excludes large shareholders or institutional investors who are especially skilled in processing public information. In addition, Fidrmuc et al (2006) document that large shareholders cannot be insiders due to some regularity conditions. As discussed earlier, their finding suggests the need for further research by considering stringent criteria for defining insiders.

Burkart et al (2002) develop a theoretical model where the founder of a firm has to hire a professional or to leave the management to his heir. In this situation, the founder faces three options: selling his entire shareholding, retaining a large portion of holding and floating the rest, and retaining the firm within the family by passing the charge to his heir. The authors show that when the founder's potential "amenity" (non-pecuniary private benefits) is very large, the founder keeps a large stake in the firm. This indeed explains why so many public companies in Canada are family-controlled. Morck et al (1998) report only 67 firms as widely-held out of 246 largest public companies at the 20% control level.[6] La Porta et al (1999) document that 30% of the largest 20 Canadian firms are family-controlled at the 10% control level. They also find 50% of medium-sized[7] publicly traded firms to be family-controlled at the same control level. The findings of these studies suggest that amenities received by the Canadian controlling families are substantial to maintain such ownership in the long run. If this is truly the case, we suspect trading by controlling families, as insiders, discloses asymmetric information. Realizing this, the market maker must establish a sufficiently wide spread.

In contrast, studies like Doidge et al (2004) report that controlling shareholders of firms that cross-list with the U.S. exchanges find it more profitable to limit their non-pecuniary private benefits when growth opportunities that cannot be attained without external funds are large. The underlying idea is that firms in countries with less stringent regulations positively signal the market by listing with the U.S. exchanges. However, the regulations of the organized exchanges in Canada and the U.S. are similar. In addition, it is less stringent for Canadian companies to cross list with the U.S. exchanges, e.g. Canadian firms are not required to comply with U.S. Generally Accepted Accounting Principals (GAAP).

2.1.4 Information-based Trading Models and the Probability of Informed Trading

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[6] Their result is based on 1988 Financial Post 500. They exclude 254 firms from their sample since those are privately held. They also report 44, 27 and 29 firms as controlled by heirs, business entrepreneurs, and other individuals or families (type unclear) respectively. Control level is determined by the voting power.

[7] Medium-size firms are defined as firms having at least $500 million or more. It should be noted that the authors considered only 10 firms in their sample.

Copeland and Galai (1983), Glosten and Milgrom (1985), and Kyle (1985) form the main basis for modern market microstructure study. However, Kyle's (1985) model considers the strategic behaviour of an informed trader in an auction setting environment.

Easley et al (1996a, 1996b) calculate the probability of informed trading, which is the crux of our interest, in the spirit of Glosten and Milgrom (1985), Easley and O'Hara (1987), and Easley et al (1997). These studies consider sequential trading models where the market participants are risk neutral and competitive. This assumption of risk neutrality and competitiveness compels the market maker quote continuously[8] to yield zero expected profit conditional on the trade type and the informed trader trade the maximum quantity in the next available opportunity.

Easley and O'Hara (1987) weaken the assumption of Glosten and Milgrom (1985) that traders are allowed to choose one unit of stock each time. They also consider information uncertainty by assuming that an information event may occur at the beginning of each trading day. In this framework, a separating equilibrium arises if the informed traders' expected profit is maximized by choosing to trade large quantity only. If this condition of profit-maximizing large quantity trading is violated, the separating equilibrium is replaced by a pooling one. Since the market maker expects only the informed traders to trade large quantity in the separating equilibrium, his Bayesian learning process now considers both trade type and trade size.[9] This price formation allows even a zero spread in the case of no information uncertainty and no informed

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[8] Lee and Ready (1991) note "specialists on both the NYSE and the AMEX are ….. required to provide continuous quotes."

[9] They also argue that price process is not Markov since the market maker sets bid price and ask price by considering the trade size.

traders. However in a pooling equilibrium, the market marker cannot distinguish between traders and therefore, sets a spread at both large and small trade sizes.

Do different trade sizes really matter? Several studies on block trading present interesting results. Holthausen et al (1987) report a permanent positive price effect that increases with block size for buyer-initiated block transactions only. Holthausen et al (1990) find significant permanent price effects for both buyer-initiated and seller-initiated block transactions. Easley and O'Hara (1987) introduce different trade sizes based on this idea and show that stock price recovers after the block sale in the presence of information uncertainty. However, block trading may bypass the market maker. In addition, a pooling equilibrium may exist in the market where large trade quantity conveys little or no information. This question is empirically answered in Easley et al (1997).

In Easley et al (1997), a model very similar to Glosten and Milgrom (1985), and Easley and O'Hara (1987) is considered. Considering the market maker's learning process is Bayesian, they show how the market maker calculates his bid and ask prices conditional on trade type. An interesting part of this study is that the authors form a likelihood function necessary to calculate the probability of informed trading. Another interesting part of this study is to model a similar likelihood function by considering different types of trade sizes into the market maker's decision problem. Based on their empirical estimations, they conclude "trade size provides no information content beyond that conveyed by the underlying transactions".[10] This means informed traders trade both large and small quantities and therefore, only a pooling equilibrium exists in the spirit of Easley and O'Hara (1987).

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[10] Page 830 of Easley et al (1997).

It should be noted that Easley et al (1997)[11] set out their model in a discrete time framework by considering binomial processes to model their likelihood function. However a binomial process approximates a Poisson process when 1) the number of observations is very large and 2) the success rate of an event is very small. This is indeed the case for most of the stocks traded in the stock exchanges: frequency is very high and the probability of any specific trade outcome at a particular time on a day is very low. For this reason, Easley et al (1996a and 1996b) consider buys and sells to follow one of independent three Poisson processes (for no-news, good-news and bad-news events) on each trading day. This method allows the authors to consider a continuous-time setting in their model.

Another interesting part of Easley et al (1996a and 1996b) is that they calculate the probability of informed trading (PIN) by estimating necessary parameters from the likelihood function. This statistic gives a direct and convenient way to test asymmetric information of different samples of interest. Easley et al (1996a) report more information-based trading in NYSE than in Cincinnati Stock Exchange. Easley et al (1996b) analyze active and infrequently traded stocks and finds higher risk of informed trading for less active stocks. If adverse selection cost is reflected in prices, it should explain returns of stocks at least to some extent. Easley et al (2002) document that PIN, used as a proxy for adverse selection costs, is significantly priced in the returns of stocks in addition to Fama-French (2002) three factors, i.e. market β, firm size and book-to-market ratio. They also report lower probability of informed trading for larger firms, a finding similar to those of several studies, e.g. Seyhun (1986), and Howe and Lin (1990), and the idea of Chiang and Venkatesh (1988).

[11] Easley and O'Hara (1992a, 1992b) also consider similar models.

These studies explain how asymmetric information induces spread in a market microstructure context. The empirical findings of these studies are very much in line with the results of Jaffe (1974), Seyhun (1986), Chiang and Venkatesh (1988), Howe and Lin (1990), Rozeff and Zaman (1988) etc. These studies report a positive relationship between the bid-ask spread and the expected losses to insiders. This indeed implies that the market considers the expected losses to insiders and adjusts market prices accordingly. This implies that any sampling criterion that strictly categorizes insiders and non-insiders should give us similar but more pronounced results with information-based market microstructure models.

2.2 Hypotheses

Section 1 of this chapter makes it clear why a competitive market maker maintains a spread. In the absence of informed traders, he is likely to maintain a very low spread as uninformed traders do not know the future movements of stock prices and cannot make abnormal profit. However informed traders can predict the future movements of stock prices. They buy before the announcement of good news and sell before the announcement of bad news. Since the market maker does not have access to any special news, he systematically losses by trading with unidentified informed traders. To recoup his losses and stay in the business, the market maker maintains a spread.

Several empirical studies, e.g. Seyhun (1986), report that some insiders have more *inside* information than others. In an effort to investigate which group can be categorized as the most informed traders, we present several theoretical and empirical studies. Individuals and families as controlling shareholders hold a substantial portion of the firm at the cost of having a less diversified portfolio, and hence they specialize their portfolio.

In addition, individuals and families are likely to hold their share in the long-run if the non-pecuniary private benefits are substantial. By considering these factors, i.e. portfolio specialization and potential amenities, we claim individuals and families to be the best informed traders to predict future movement of stock prices. Realizing this, the rational market maker is going to increase the spread for those stocks. Based on this discussion, we are motivated to test the following two hypotheses:

Hypothesis 1: Average bid-ask spread of family-controlled firms is higher than that of widely-held firms.

Hypothesis 2: PIN of family-controlled firms is higher than that of widely-held firms.

Therefore, we expect to reject the null hypotheses presuming equality of spread and PIN across the two classes of firms in favour of the alternate hypothesis with PIN of family-controlled firms being higher than that of widely-held firms.

Trading frequency is higher at the beginning and end of each trading day and thereby follows a U-shaped curve (see Lee and Ready (1991)). By considering one period per day, Easley et al (1996a, 1996b, 1997) essentially assume that trade arrival rates of informed and uninformed traders in the Poisson processes are constant all day. We want to test whether their assumption is empirically valid.

A homogeneous Poisson process is characterized by its rate parameter λ, which is the expected number of "events" or "arrivals" that occur per unit time. In such a Poisson process, λ remains constant over time.[12] If one day is considered as an event period, we therefore directly assume that arrival rates of informed and uninformed traders are constant throughout the day. The U-shaped trading frequency may imply multiple event periods. Motivated by this discussion, we test the following hypotheses.

[12] see http://en.wikipedia.org/wiki/Poisson_process

Hypothesis 3: Information events may occur multiple times throughout the trading day as opposed to only at the beginning of the day.

Hypothesis 4: Arrival rates of uninformed traders change over time within a trading day.

Hypothesis 5: Arrival rates of informed traders change over time within a trading day.

We expect to reject null hypotheses that the probability of information events occurring later in the trading day is zero, and trader arrival rates are equal in different periods of the day. The U-shaped daily trading frequency sets grounds for the fourth and fifth hypotheses. However, we find no relevant study to form expectation on Hypothesis 3 and therefore, we only remark that requiring information events to occur only at the beginning of any given trading day seems overly restrictive and is best left as an empirical question.

Chapter 3

Sample Construction, Data Availability and Methodology

This chapter discusses the sample construction, data availability, and methodology used in this study. Section 1 describes the procedures followed to form the two classes of firms. Section 2 details the intraday data availability of the sample firms. It also presents potential data problems and sets specific mechanisms to avoid such problems. Section 3 discusses methodologies to test hypotheses of Chapter 2. We also consider a different formulation of PIN in this section, and based on this, we develop the hypothesis that our modified PIN is significantly less than the PIN of Easley et al (1996b). The last part of this section considers methodologies used to estimate parameters useful in PIN calculation.

3.1 Sample Construction

In this study, we use Canadian-based publicly traded firms cross-listed with U.S. exchanges over the period of 2004-05. We consider Canadian-based firms for the following reasons. Morck et al (1998) note that Canada and the U.S. have very similar endowments, technology, and human capital, but markedly different ownership structure of their largest firms. Many large publicly traded firms are owned by individuals, families, or groups of individuals in Canada whereas in the U.S. this ownership structure is relatively rare. We hand collect the cross-listed firms for every month from TSX Review and TSX E-Review[13] over our sample period. We record a minimum of 183 firms in January 2004 and a maximum of 252 firms in December 2005. The number of

[13] Toronto Stock Exchange publishes this under the authority of the Board of Directors of TSX Group. We collected firm names from the "Interlisted Stocks" section.

cross-listed firms has an increasing trend over the sample period with the only exceptional month being January 2005.

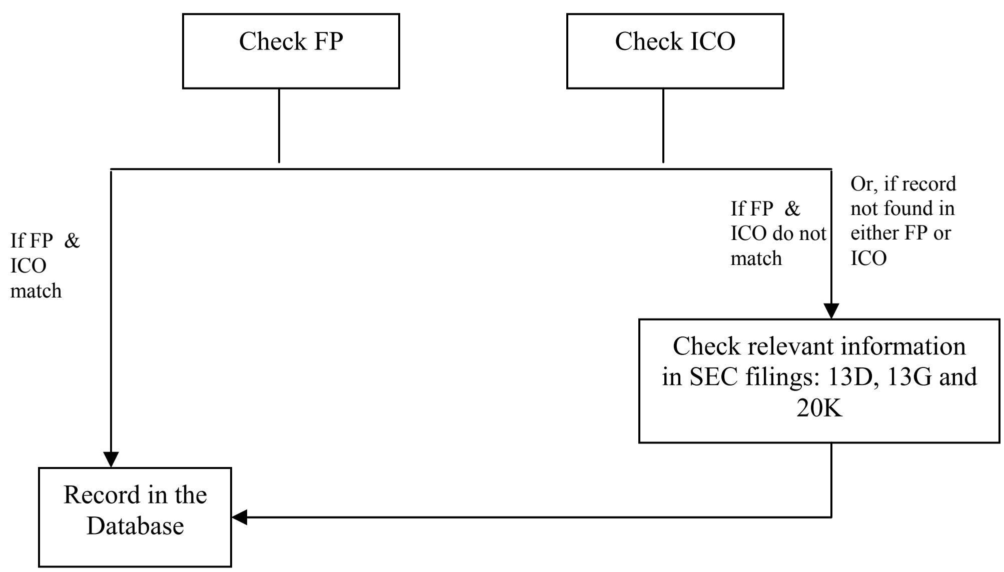
To classify whether a firm is family-controlled or widely-held, we use the 10% voting right rule of La Porta et al (1999). This threshold is sufficient to control the decision making process of a firm. In addition, several available databases report controlling shareholders from this level. It should be noted that finding specific ownership structures, e.g. pyramid structure as defined in La Porta et al (1999), is beyond the scope of this study. We simply track whether a firm has *any* controlling shareholder. If there is no controlling information, we record it as a widely-held company. However, if there is one or more controlling shareholders, we check whether any of the controlling shareholder(s) is an individual or are from the same family. We record firms as family-controlled if we find individuals or family members as groups are the ultimate owners. Some companies may also be controlled by another company. In such situations, we track the ownership structure of the controlling company in the same way and define the ultimate ownership structure. Managers of Company A may jointly form a Private Company B to control Company A. We also categorize Company A as family-controlled in such situations. Private Company B may perform any business, e.g. manufacturing, investment advising, etc.

We use 1) Financial Post (FP) Surveys of industrials (2003), Financial Post Surveys of Mines and Energy Resources (2003) and online FP Corporate Survey, 2) 2004-05 Inter-corporate Ownership (ICO) CDs provided by Statistics Canada, and 3) the U.S. Security Exchange Commission filings (schedule 13D and 13G, and 20F)[14] to track

[14] Firms file 13D (General Statement of Beneficial Ownership), 13G (Statements of Beneficial Ownership) and 20-F (Annual Reports) with the U.S. SEC. It should be mentioned that both 13D and 13G report

the ultimate ownership structure. Both FP surveys and ICO report significant ownership at and above 10% while the U.S. SEC filings require documentation from 5%. To avoid any error in classifying firms, we follow a stringent classification procedure (see Figure 3.1 below) at the beginning of the sample period for each of the sample firms.

Figure 3.1: Procedure to classify firms



Firms are thus classified as family-controlled or widely-held on January 1, 2004. We repeat the same procedure to classify firms on December 31, 2005. We find 162 firms to have data for the entire sample period. Among these firms, 43 firms are found either to have altered their ownership status within the sample period or have undefined foreign ultimate owners that cannot be traced with the available database. In addition, some of the firms with altered ownership statuses have been acquired shortly after the event. As noted earlier, the existing literature implies that individuals, families or groups

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beneficial ownership at and above 5% level. However these filings differ in some aspects. Schedule 13G is a shorter version of 13D. Schedule 13G can be filed instead of 13D when a firm's beneficial owner 1) holds more than 5% but less than 20% of the voting power of any class of shares, 2) does not hold securities for controlling purpose (passive investors) and 3) is a registered financial institution. We observe that FP and ICO use information from both 13D and 13G. And several previous studies, e.g. La Porta et al (1999), use FP surveys.

retain control over firms only if they expect large potential amenities. We believe this will be the case if those controlling groups retain such power in the long-run. We expect a change in the controlling shareholding if retention of control is not profitable. This gives us reason to exclude those 43 firms from the main study. However, we do use some of these firms to conduct an event study involving a change of ownership event. From the remaining 119 firms, we find 64 (approx. 54%) widely-held and 55 (approx. 46%) family-controlled firms.

3.2 Data Availability

The market microstructure setup of the organized exchanges is different from that of over-the-counter (OTC) markets. Multiple market makers can be found in the OTC market. Different factors like less stringent regulations in the OTC market may also result in higher bid-ask spreads. For this obvious difference in the market setup, many studies, e.g. Seyhun (1986) and Howe and Lin (1990), consider investigating firms listed with NYSE/AMEX and NASDAQ separately. Following these, we analyze the 38 firms that are listed only with NASDAQ separately. This results a sample size of 81 firms that are listed with either NYSE or AMEX.

Of these 81 firms, we find 73 firms to have intraday trading data from the NYSE Trade and Quote (TAQ) database for the entire two-year period. 44 widely-held and 29 family-controlled firms listed with NYSE or AMEX form the ultimate samples for our main study. In addition to analyzing these two samples, we also investigate how the market maker forms the probability of informed trading for firms that were found to alter ownership status. We were able to find the exact dates of such events from 13D or 13G[15] of the U.S. SEC filings for 10 firms listed with NYSE/AMEX. Finally, 9 of the 10 firms

[15] We consider the date listed in the "Date of Event Which Requires Filing of this Statement" section.

were found to have at least 60 days of intraday trading data around the event from TAQ database. [16]

Several procedures have been considered to minimize data errors observed in NYSE TAQ database. These are:

1. Motivated by a series of papers by Easley et al (1996a, 1996b, 1997) we assume that market makers quote bid and ask prices simultaneously. Therefore, we omit trades and quotes that exist before such meaningful quotes of a day (for example, those due to the opening auction process). We also exclude trades at the beginning of the day that occur at the midpoint price, i.e. average of ask and bid prices, and for which we cannot perform the tick test for the lack of previous trade prices (described in Section 3).
2. For the same reason, trades and quotes are omitted if either ask or bid price is equal to or less than zero.
3. In the presence of informed traders, a positive spread must exist. Hence we omit trades and quotes if the spread is equal to or less than zero. We also exclude quotes if spread is greater than bid price.
4. Furthermore to avoid misleading quotes, we exclude quotes with spread more than $5. Although the market maker is expected to increase the spread in an anticipation of informed trading, a spread greater than $5 is unreasonable for firms in our sample. Markets for securities with alarming level of adverse selection cost are halted by the authority. In addition, many studies, e.g. Chordia and Roll (2001), use this criterion.

[16] Easley et al (1997) and Easley et al (2002) consider data for 60 trading days. Easley et al (2002) note, "the model can be estimated using as little as 60 trading days of data provided there is sufficient trading activity". We find a lowest of 46 trades/day of these nine firms.

5. We assume that all market markers are competitive and quote similar bid and ask prices. Consequently, we only consider the best available bid and ask prices, i.e. highest price for bid and lowest price for ask.
6. To avoid erroneous quotes and trades, we restrict successive bid and ask prices to change by less than 25%.[17]

3.3 Methodology

3.3.1 Bid-Ask Spread

Our objective is to compare the average bid-ask spread for family-controlled and widely-held firms. Spread is defined in many different ways. We analyze relative spread and effective spread in this study. Relative spread is defined as the following:

$$\frac{\{ask\ \ price - bid\ \ price\}}{mid\ \ price}.$$

Here midpoint price is just the average of bid and ask prices. For consistency and to compare spreads of different firms, we calculate effective spreads as a percentage of midpoint prices as the following:

$$\frac{2 \times \left|Transaction\ \ price - mid\ \ price\right|}{mid\ \ price}.$$

We calculate average relative spreads and average effective spreads as the percentage of respective midpoint prices for all sample firms. Since we have different sample sizes for family-controlled and widely-held firms, we use the following statistic based on independent samples to test whether average relative spread and effective

[17] Dow Jones Industrial Average (DJIA) index fell by 22% on Black Monday, October 19, 1987. Source: *www.wikipedia.org*. So it is unreasonable that successive prices change by more than 25% for firms we sample.

spread of family-controlled firms are significantly different from those of widely-held firms.

$$Z = \frac{\overline{x}_{FC} - \overline{x}_{WH}}{\sqrt{\frac{s_{FC}^2}{n_{FC}} + \frac{s_{WH}^2}{n_{WH}}}},$$

where $\overline{x}_{FC}$ and $\overline{x}_{WH}$, s_{FC}^2 and s_{WH}^2, and n_{FC} and n_{WH} are sample means, variances, and sample sizes of family-controlled and widely-held firms. It should be mentioned that sample variances for both samples are expected to approximate population variance when n_{FC} and n_{WH} are greater than thirty. Since the sample size of family-controlled firms is marginal, we also perform the normal approximation of the Mann-Whitney non-parametric test (the Mann-Whitney Z).

The Mann-Whitney *U* test is based on two independent samples. The following steps are followed to calculate this test statistic. At first, we pool the observations of two samples and rank them in ascending order. We then sum up the ranks of the observations from the first sample. Let R_1 be this sum. Then the Mann-Whitney U test statistic is

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1 .$$

Here, n_1 and n_2 refer to the numbers of observations available for the first and second samples respectively. The Mann-Whitney approximates the normal distribution as both sample size increases. The approximation is adequate if each sample have at least 10 observations. The normal approximation of the Mann-Whitney *U* test statistic is calculated as the following:

$$Mann - Whitney\ Z = \frac{U - \mu_U}{\sigma_U},$$

where $\mu_U = \frac{n_1 n_2}{2}$ and $\sigma_U{}^2 = \frac{n_1 n_2 (n_1 + n_2 + 1)}{12}$.

For large Mann-Whitney Z statistic, we reject the null hypothesis that two population distributions have the same central location. Along with the standard Z test statistic, we use this Mann-Whitney Z extensively in our study.

3.3.2 The Probability of Informed Trading

In a series of papers, Easley et al (1996a, 1996b, 1997) develop a model that calculates quotes and the probability of informed trading. Because of the apparent importance of such model to the current study, a detailed explanation is provided.

In a sequential trading model, traders trade a single stock with the market maker. At the end of the day, the asset has a value V, a random variable. The asset value conditional on good news is $\overline{V}$ and conditional on bad news, it is $\underline{V}$. The trading process is as follows: The market maker quotes bid and ask prices. Traders arrive at the trading post one by one and each has the opportunity to buy or sell one unit of asset. After each round of trading, the market maker is free to revise his quotes based on the information revealed by the trade. As a risk-neutral and competitive market maker, he continuously quotes and maintains zero expected profits during the trading day. He also knows the probabilistic structure of the arrival rates of informed and uninformed traders. Some traders, known as *informed traders*, have special information about the true asset value.

An information event may occur at the beginning of the trading day (with a probability of α). If the information event occurs, the informed traders know whether it is bad (with probability δ) or good (with probability 1 – δ) news. If the information event is good news (bad news), competitive informed traders are assumed to arrive at the rate of μ and buy (sell) the stock with probability 1. Uninformed traders are not aware of the information event and therefore, their arrival rate and the likelihood of buying or selling are independent of any information event. Assuming that they are equally likely to buy and sell, the arrival rate of uninformed buyers and sellers is ε regardless of the information event.[18] In this setup, $\mu + \varepsilon$ and ε are the arrival rates for buyers and sellers on good-news days. Similarly, ε and $\mu + \varepsilon$ are the arrival rates for buyers and sellers on bad-news days. On days with no information event, only uninformed buyers and sellers arrive, so ε is the arrival rate for both buyers and sellers.

According to Easley et al (1996a, 1996b), the market maker does not know whether it is going to be a good-, bad-, or no-news day at the beginning of the day. However he has information on the probability structures of parameters (α, δ, μ, ε) and believes that any of the three possible events may occur. He knows that good-, bad-, and no-news events occur with probabilities $P_g(0) = \alpha(1-\delta)$, $P_b(0) = \alpha\delta$, and $P_n(0) = (1-\alpha)$ respectively. Considering this, he forms his bid and ask prices in the following way:

$$\begin{aligned} b(t) &= E[V|t] - \frac{\mu P_b(t)}{\varepsilon + \mu P_b(t)}(E[V|t] - \underline{V}) \\ a(t) &= E[V|t] + \frac{\mu P_g(t)}{\varepsilon + \mu P_g(t)}(\overline{V} - E[V|t]) \end{aligned}.$$

Here $\mu P_b(t)/[\varepsilon + \mu P_b(t)]$ refers to the probability of informed selling if it turns out to be a bad event day. Probability factor in the ask price can be explained similarly. Both bid and ask prices take the probability of informed trading into consideration. In the absence of informed traders, bid price equals ask price and the market maker does not revise his prices. On the other hand, bid and ask prices equal $\overline{V}$ and $\underline{V}$ respectively in the absence of uninformed traders. Considering the probabilities of both informed buying and selling,

[18] Easley et al (1996a, 1997) consider equal buy and sell arrival rates for uninformed traders. They note "it seems a reasonable representation of noise trader behavior".

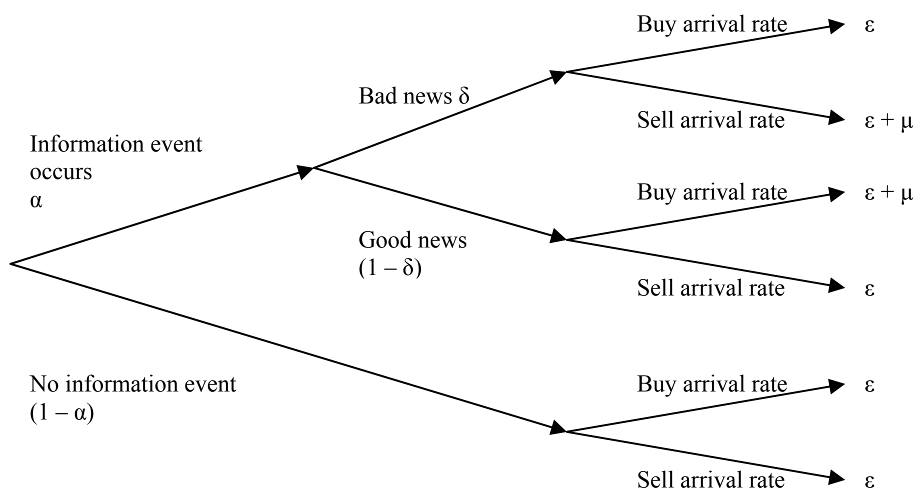
and the fact that good and bad events are equally likely,[19] the market maker easily finds the probability of informed trading (PIN) at the beginning of the day.

$$Considering\ \ P_g(t=0) = P_b(t=0) = \delta,$$

$$PIN = \frac{\alpha\mu}{\alpha\mu + 2\varepsilon}$$

This is how PIN is defined in Easley et al (1996b). Before we proceed further, a more careful analysis of the tree diagram of the trading process of Easley et al (1996b) is warranted. The calculation of PIN can be derived in a simpler fashion from Figure 3.2.

Figure 3.2: Tree diagram of trade arrival rates[20]



Note: Information event occurs with probability α. δ is the probability that the information event is bad news. Informed and uninformed traders arrive at μ and 2ε respectively. On good news days, buyers and sellers arrive at (ε + μ) and μ respectively. On bad news day, buyers and sellers arrive at ε and (ε + μ) respectively. On no news days, both traders arrive at ε.

Let I_t denote informed trading at time *t* and *n*, *g* and *b* denote no-news, good-news and bad-news respectively. If Pr{Φ} is the probability of Φ, then,

[19] Easley et al (1996b) find that δ = 0.5 is a good approximation. See footnote 10 of Easley et al (1996b).
[20] This diagram is from Easley et al (1996b).

$$Modified\ \ PIN = \Pr\{I_0|n\}\Pr\{n\} + \Pr\{I_0|g\}\Pr\{g\} + \Pr\{I_0|b\}\Pr\{b\}$$

$$= 0 + \left\{\frac{\mu}{\mu + 2\varepsilon}\right\}\{\alpha(1-\delta)\} + \left\{\frac{\mu}{\mu + 2\varepsilon}\right\}\alpha\delta$$

$$= \left\{\frac{\mu}{\mu + 2\varepsilon}\right\}.$$

This apparent discrepancy in calculating the PIN may lead to different conclusions. If the value of α is very close to 0 or 1, the numerical values of both PINs would be similar, otherwise the modified PIN should be strictly smaller. However it is unlikely to find boundary values for α for most, if not all, of the NYSE and AMEX firms since information events occur sporadically. Hence, we empirically investigate in this study whether our formulation of PIN is significantly less than the conventional PIN calculation. We test for the difference between the means of the two PIN calculations (matched pairs) by using the *t* test (on the difference of matched pairs), and the normal approximation of the Wilcoxon non-parametric test (the Wilcoxon Z). It should be mentioned that the normal approximation is adequate for thirty or more observations. Based on this discussion, we develop the following hypothesis.

Hypothesis 6: The modified PIN is less than the PIN defined by Easley et al (1996b).

As before, we test this by attempting to reject the null hypothesis that the two PINs are equal against a one-tailed alternative. Easley et al (1996a, 1996b, 1997) develop a likelihood function that can be used to estimate the parameter vector θ = (α, δ, μ, ε). We should also note that PIN, as a measurement of asymmetric information cost, is a function of three estimated parameters, α, μ and ε. Therefore, for similar α and μ, and different ε, it is very likely to get very different probability of informed trading.

Simple comparative statics shows that for a small change in α, both conventional and modified PIN increases.

$$\textit{Conventional PIN}: \frac{\partial}{\partial \alpha}\left(\frac{\alpha\mu}{\alpha\mu + 2\varepsilon}\right) = \frac{2\varepsilon\mu}{(\alpha\mu + 2\varepsilon)^2},$$

$$\textit{Modified PIN}: \frac{\partial}{\partial \alpha}\left(\frac{\alpha\mu}{\mu + 2\varepsilon}\right) = \frac{\mu}{(\mu + 2\varepsilon)}.$$

For a change in α, modified PIN increases more than the conventional PIN given α is close to one. However, conventional PIN increases more than our modified PIN for α close to zero. Further analysis shows that both PINs decrease with ε and increase with μ, which is expected in these models.

For a review of the model, our discussion follows by explaining the likelihood function on a no-event day. Since only uninformed traders trade on such days, arrival rates of both buyers and sellers are the same. Considering a continuous-time framework, all of the arrival rates follow independent Poisson distributions. Therefore the likelihood function of observing B buys and S sells during total time, T, of a no-event trading day is:

$$e^{-\varepsilon T}\frac{\varepsilon T^B}{B!}e^{-\varepsilon T}\frac{\varepsilon T^S}{S!}.$$

Similar likelihoods can be formed for a good-news day and a bad-news day. B buys and S sells follow any of the three Poisson processes each day. Since there is uncertainty regarding the information event in a particular day, a weighted average of good-, bad- and no-news day likelihood functions are considered with their respective probabilities, α(1 – δ), αδ, and (1 – α), to form the following daily likelihood function:

$$L[(B,S)|\theta] = \begin{Bmatrix} \alpha(1-\delta) * e^{-(\mu+\varepsilon)T} \dfrac{[(\mu+\varepsilon)T]^B}{B!} e^{-\varepsilon T} \dfrac{(\varepsilon T)^S}{S!} \\ + \alpha\delta * e^{-\varepsilon T} \dfrac{(\varepsilon T)^B}{B!} e^{-(\mu+\varepsilon)T} \dfrac{[(\mu+\varepsilon)T]^S}{S!} \\ + (1-\alpha) * e^{-\varepsilon T} \dfrac{(\varepsilon T)^B}{B!} e^{-\varepsilon T} \dfrac{(\varepsilon T)^S}{S!} \end{Bmatrix}.$$

This is the likelihood function the market forms for a particular day. Since the days are considered independent, the likelihood function over I days will be the product of daily likelihoods:

$$L(M|\theta) = \prod_{i=1}^{I} L(B_i, S_i|\theta).$$

We maximize this likelihood function to estimate the parameter vector θ and therefore calculate the PIN for both of our samples. One of our objectives is to test whether different trade arrival rates on a trading day imply different information events. Since the assumption that information events occur only once before each trading day is an abstraction [Easley et al (1997)], we consider two-event periods (before and after 1:00 pm) and three-event periods within a trading day (before 11:00 am, from 11:00 am to 2:30 pm and after 2:30 pm).[21] Otherwise, we consider the same assumptions of the model presented.

To compare whether PIN of family-controlled firms is significantly different from that of widely-held firms, we use the Mann-Whitney Z test. We also use the normal approximation to a similar non-parametric test, namely the Wilcoxon test, to investigate whether PINs of any sample are significantly different across different periods of trading days. The Wilcoxon test is based on matched sample sizes whereas the Mann-Whitney test is based on different sample sizes.

[21] As stated earlier, these event periods are classified in the spirit of Lee and Ready's (1991) observation.

We also conduct an event study approach to analyze the PINs of family-controlled and widely-held firms in Section 4.5. We find only 9 firms with the minimal requirement of data to alter their ownership status during our sample period. Since only these firms are considered in the event study, we cannot use the Wilcoxon Z test statistic. Rather, we use the Wilcoxon T test statistic. Like other non-parametric tests, the Wilcoxon test is based on rankings. At first, we take the absolute difference of the observation of two matched samples. After discarding pairs that have zero differences, we rank the rest in ascending order. The ranks for positive and negative differences are summed separately. The Wilcoxon T is the smaller of these sums. If the sums of the ranks for positive and negative differences are very different, we would be suspicious of the null hypothesis that the differences are centered around zero. Therefore for very low value of the T statistic, we reject the hypothesis.

When there are more than 20 non-zero matched pair differences, the normal distribution approximates the Wilcoxon T. For convenience, we term this normal approximation as the Wilcoxon Z. This is calculated as

$$Wilcoxon\ Z = \frac{T - \mu_T}{\sigma_T},$$

where $\mu_T = \frac{n(n+1)}{4}$ and $\sigma_T^2 = \frac{n(n+1)(2n+1)}{24}$. For a large Wilcoxon Z test statistic, we reject the null hypothesis that the population differences are centered around zero.

So far we have illustrated two non-parametric tests, namely the Mann-Whitney test and the Wilcoxon test. The Wilcoxon test can be employed for two samples having equal number of observations. In contrast, the Mann-Whitney test is appropriate when we have two independent samples with different numbers of observations. We also face situations where we need to compare three samples, e.g. PIN of family-controlled firms across first, second and third sessions. In such situation, we use the Kruskal-Wallis test statistic. We explain below how this test statistic is calculated.

Let n_1, n_2 and n_3 denote the numbers of observations of three samples. Like other non-parametric tests, we at first pool observations of all samples (denoted by n) and rank them in ascending order. We denote R_1, R_2 and R_3 the sum of ranks of the first, second and third samples. Then we calculate the Kruskal-Wallis test statistic as the following.

$$Kruskal-Wallis\ W = \frac{12}{n(n+1)}\left[\frac{R_1^2}{n_1}+\frac{R_2^2}{n_2}+\frac{R_3^2}{n_3}\right]-3(n+1).$$

This test statistic follows a χ^2 distribution with 2 degrees of freedom. For a large test statistic, we reject the null hypothesis of equality of the three population means.

3.3.3 Trade Classification

To estimate the parameters from the likelihood function, we must know the trade types, e.g. buys or sells. NYSE TAQ database has information on quotes and trades. However, it does not contain trade classification records.

Lee and Ready (1991) analyze the tick test, reverse tick test, and quote rule for trade classification. In the tick test, trades can be classified into four categories, namely uptick, zero uptick, downtick and zero downtick. If the current trade price is higher (lower) than the previous trade price, the trade is referred to as uptick (downtick). Since buying pressure induces an increase in trade price, trades at upticks are considered buys. Similarly, trades at downtick are sells. If consecutive trade prices are the same, the trade is classified as the previous one. If the previous trade is uptick (downtick), the current trade is classified as zero uptick (zero downtick). Zero upticks and zero downticks are categorized as buys and sells respectively. Every trade is classified in this way. In this procedure, a trade is classified by comparing the current price movement relative to the price of the previous one. The reverse tick test follows an opposite algorithm: it classifies trades by comparing the current trade price change to the price of the next trade. Lee and Ready (1991) report that the tick test outperforms the reverse tick test.

Lee and Ready (1991) also document that it is likely to find most of the current trade prices within the concurrent bid-ask spreads since trades are recorded after quotes. They document that quotes that are at least 5 seconds old (effective quotes) better correspond to current trade prices. This 5 second delay arises from a delay in recording trade data.

Easley et al (1996a, 1996b, 2002 etc.) combine the tick test and quote rule of Lee and Ready (1991) to classify trades. According to the quote rule, trades are considered buys (sells) if they occur above (below) the midpoint of effective quotes. However trades may also occur at midpoints. Classification of these trades follows the tick test – if positive price change is found in consecutive trades, we classify the trade as buy and otherwise sell. Although there is a possibility of misclassification, we follow this procedure as it is standard and widely accepted in the literature [Easley et al (2002)].

3.3.4 Maximum Likelihood Estimation

Easley et al (1996a, 1996b) finds the likelihood function to be well-behaved in empirical analysis. However, we find a problem in estimating the likelihood function with Poisson distribution for firms with very high daily average arrival rates using the same structure.[22] To circumvent this situation, we use the normal approximation to the Poisson process. For very large values of Poisson rate (λ), $N \sim \text{normal}(\lambda, \lambda^2)$ is an excellent

[22] With standard spreadsheet software, the Poisson process shows error for very high daily average arrival rates.

approximation of the Poisson process. Furthermore, N ~ normal(λ, λ^2) is a good approximation of the Poisson distribution if $\lambda > 10$ and a continuity correction is performed. If x is a non-negative integer, then $P(X \leq x)$ is replaced with $P(X \leq x + 0.5)$ for the continuity correction.[23] Consequently, we estimate the likelihood function considering either Poisson or normal distribution. For more accurate estimation, we consider $\lambda > 20$ the cut-off point to determine which distribution to follow.

Moreover, the likelihood function over I days is defined as the product of daily likelihoods. To help numerical stability for the maximization, we consider the natural logarithm of the likelihood function.

In the likelihood function, α and δ are the probabilities of information event and bad news respectively and, therefore, their values should be bounded within 0 and 1. In addition, arrival rates ε and μ cannot be negative. We estimate unconstrained parameters – *a*, *d*, *e* and *m* – with different initial values by maximizing the likelihood function and then transform those values to α, δ, ε and μ respectively.[24] Different initial values are used to avoid local maximization.

We put restrictions in the likelihood function to measure whether the estimated parameters in the morning is significantly different from those in the afternoon. For example, to test whether α_m (information event before 1:00 pm) is significantly different from α_a (information event after 1:00 pm) we put $\alpha_m = \alpha_a$ as the restriction. If the restriction is in fact true, then $\ln L_R$ is not expected to be significantly less than $\ln R_U$. It may be noted that the LR test statistic, $2\{\ln(L_R)-\ln(L_U)\}$, asymptotically follows a chi-

[23] Source: http://en.wikipedia.org/wiki/Poisson_distribution

[24] Transformation method: $\alpha = \exp(a)/\{1+\exp(a)\}$, $\delta = \exp(d)/\{1+\exp(d)\}$, $\varepsilon = \exp(e)$ and $\mu = \exp(m)$

squared (χ^2) distribution with degrees of freedom equal to the number of restrictions, here for example, 1.

Chapter 4

Empirical Findings

Our main objective is to investigate the PINs of family-controlled and widely-held firms. However, some of the assumptions used by Easley et al (1996a, 1996b) to calculate the PIN are quite strong. In the previous chapters, we outlined that information events may not only occur at the beginning of the day. In addition, trading frequency for frequently traded stocks follows a U-shaped curve. Based on this discussion, we consider multiple periods within trading days. We estimate the likelihood function by considering the entire day as one period, as two periods, and as three periods. We present the findings separately based on the number of daily periods. We also consider an event study about the event that a firm changes its ownership structure in this chapter.

4.1 Analysis of Spread

A primary motivation of this study was to analyze whether the average relative spread and the average effective spread as a percentage of midpoint price of family-controlled firms are higher than those of widely-held firms. Table 4.1 on the next page reports the findings on Canadian firms cross-listed with NYSE/AMEX. The Mann-Whitney Z test is performed since sample size of family-controlled firms is marginally less than 30. We find all test statistics to be significant for relative spread. In addition, the average relative spread of family-controlled firms is higher than that of widely-held ones. This provides enough evidence in favour of our first hypothesis. Therefore, we do not reject the first hypothesis that the average spread is higher for family-controlled firms. However, we find confounding results when effective spread is considered. Though the average effective spread of family-controlled firms is higher than that of widely-held ones, none of the test statistics are significant at even 5% significance level.

Table 4.1: Summary Statistics and Hypothesis Testing of Spread

Statistics	**Relative spread as a % of midpoint price**	**Effective spread as a % of midpoint price**
Mean, $\bar{x}$	$\bar{x}_{FC} = 1.602$ $\bar{x}_{WH} = 0.885$	$\bar{x}_{FC} = 0.655$ $\bar{x}_{WH} = 0.581$
Standard deviation, s	$s_{FC} = 0.019$ $s_{WH} = 0.008$	$s_{FC} = 0.007$ $s_{WH} = 0.006$
Sample size, n	$n_{FC} = 29$ $n_{WH} = 44$	$n_{FC} = 29$ $n_{WH} = 44$
Hypothesis testing	$\bar{x}_{FC} = \bar{x}_{WH}$	
Z statistic (large sample)	1.915**	0.472
Mann-Whitney Z statistic	2.108**	1.026

Null hypothesis of $\bar{x}_{FC} = \bar{x}_{WH}$ is tested for both spread calculations. *** and ** depict significance of test statistics at 1% and 5% level respectively. Z statistic of 1.915 is significant at or above 2.81% level.

Effective spread is calculated by deducting the midpoint price from the transaction price. This calculation effectively reduces the actual spread, a fact that is evident from the above table, and consequently, may not capture the desired information effect since trades within the quotes may come from traders who can credibly claim to be uninformed.

We should also note that bid-ask spread considers asymmetric information cost and the cost of immediacy and trading. In the literature review Chapter (Section 3), we argued that individuals or families hold substantial ownership of a firm at the expense of a less diversified portfolio and hence, specialize their portfolios. Since these controlling groups are better informed, the market maker faces substantial losses by trading with them. To recoup these losses from the uninformed traders, he maintains a higher spread. The analysis on bid-ask spread statistically shows that the market maker maintains a higher spread for family-controlled firms. But, which cost is causing the spread of family-controlled firms to be higher is not clear (most of the family-controlled and widely-held stocks in our sample are frequently traded, and therefore, illiquidity should not be of much concern). In the following sections, we therefore analyze whether higher spread of family-controlled firms is caused by the asymmetric information cost.

4.2 One Period per Day – A Conventional Approach

Considering a day as a period, we restrict disclosure of any information event during the rest of the day. In addition, arrival rates for the entire day are supposed to be constant in the independent Poisson processes. Later in this study, we explore whether these assumptions have any serious consequences. One point of interest is to see whether total number of buys and sells approximates the total number of informed and uninformed traders. We present in Table 4.2 the summary statistics of buys and sells along with informed and uninformed trading for this purpose. We find that the total amount of informed and uninformed trading is higher than the total number of buys and sells in both family-controlled and widely-held cases (one would expect $\alpha\mu + 2\varepsilon$ to be equal to the sum of the averages of buys and sells). For interested readers, we enclose the firm-wise statistics in Appendix 1. It should be noted that the averages of alpha and delta for family-controlled firms are 0.249 and 0.333 respectively whereas they are 0.277 and 0.293 respectively for widely-held firms. This implies that the market maker perceives, on an average, an alpha of 0.249 for family-controlled firms. He also perceives with probability of 0.333 that the information event is bad news. In case the trading day turns

Table 4.2: Summary statistics of buys and sells with informed and uninformed trading

	Family-controlled firms		Widely-held firms	
Sample Statistics	***Buys***	***Sells***	***Buys***	***Sells***
Minimum	2.024	2.058	2.990	2.950
Maximum	1,365.454	1,178.618	1,613.022	1,544.712
Mean	219.399	187.826	381.837	321.215
Standard Deviation	302.819	260.710	432.490	367.192
Estimates	***Epsilon***	***Mu***	***Epsilon***	***Mu***
Minimum	1.942	8.913	1.973	7.596
Maximum	1,000.865	745.152	1,163.842	875.335
Mean	177.387	184.337	287.931	307.531
Standard Deviation	228.929	168.827	301.230	247.014

Note: Epsilon and mu refer to uninformed and informed trading respectively.

out to be a bad-news day, the market maker also predicts for an average family-controlled firm that a total of 539 trades, 184 of which are informed, are likely to occur. Since informed traders know about the bad news, they will only sell whereas uninformed traders are equally likely to buy and sell. Presumably the market maker makes more specific forecasts for individual firms. Similar explanation can be illustrated for widely-held firms.

To formally analyze whether the higher spread of family-controlled firms is induced by the asymmetric information cost, we compare PINs of family-controlled and widely-held firms. If the market maker observes a higher level of information asymmetry for family-controlled firms, we expect 1) the average PIN_{FC} to be higher than the average PIN_{WH} and 2) the test statistics to be large enough to reject the null hypothesis, i.e. reject $PIN_{FC} = PIN_{WH}$ in favour of the alternative hypothesis, $PIN_{FC} > PIN_{WH}$.

Based on the PINs presented in Appendix 2, we calculate the average and standard deviation of PINs of family-controlled and widely-held firms in Table 4.3. Two main findings of the descriptive statistics are 1) average modified PIN of family-controlled firms is not higher than that of widely-held firms and 2) numerical values of the modi-

Table 4.3: Summary Statistics and Hypothesis testing of PINs – One Period per Day

Statistics	**Family-controlled firms**	**Widely-held firms**
PIN: Easley et al (1996b)		
Mean, $\bar{x}$	0.166	0.163
Standard deviation, s	0.082	0.064
Sample size, n	29	44
Modified PIN		
Mean, $\bar{x}$	0.103	0.111
Standard deviation, s	0.030	0.037
Sample size, n	29	44
Hypothesis testing	Z statistic (large sample)	Mann-Whitney Z statistic
	$\overline{PIN}_{FC} = \overline{PIN}_{WH}$	$\overline{PIN}_{FC} = \overline{PIN}_{WH}$
PIN: Easley et al (1996b)	0.159	0.653
Modified PIN	0.947	0.496

No test statistic is significant at 5% level. Every firm has 500 trading days for the maximum likelihood estimation.

fied PIN calculation are lower than the conventional PIN calculation. The second finding implies that information events occur after sporadic intervals and therefore, its probability, α, empirically satisfies $0 < \alpha < 1$ (strong form of inequality). Since the modified PIN does not consider multiplying α with μ in the denominator, we later perform a formal test to verify whether the modified PIN calculation is less than the PIN developed by Easley et al (1996b).

We perform the Mann-Whitney test in addition to the Z test to verify the null hypothesis for two reasons.[25] These are 1) we do not know the exact distribution of the estimated parameters and 2) sample size of family-controlled firms is less than 30, which is marginal. For low Mann-Whitney Z test statistics, we cannot reject the null hypothesis that the PIN of family-controlled firms is equal to that of widely-held firms for both

[25] We perform several non-parametric tests in the later sections of this study for the same reasons.

methods of PIN calculations. The support for the null hypothesis, in turn, provides evidence against Hypothesis 2.

Testing the null hypothesis necessarily involves accurate model specification. Considering this, any hypothesis testing involves a joint test of the null hypothesis and the underlying model specification. The PIN estimations assuming information event only at the beginning of the trading day and constant arrival rates throughout the day may not be good approximations if those assumptions are not empirically valid. In addition, constant arrival rates of uninformed and informed traders throughout the whole day is very implausible given the U-shaped trading frequency typically observed and the market efficiency doctrine. For these reasons, we consider several periods within each trading day in an effort to get more accurate PINs. An economic interpretation of the findings of Table 4.3 is contingent on the empirical validity of the assumptions.

4.3 Two Periods per Day

Informed traders will trade following an information event at the beginning of the day. The market maker does not know whether such an event has occurred. Accordingly, he forms his prior belief by considering all events, i.e. good news, bad news, and no news. Trade begins and the Bayesian market maker updates his belief based on trade type and arrival rates. In an ideal efficient market, it should not take long for the Bayesian market maker to identify the presence of informed traders and update the quotes to avoid losses from the informed traders. On the other hand, competitive informed traders have the incentive to trade before the market maker realizes their presence. Therefore, the assumption of constant informed trade arrival rate is unlikely to be valid. In addition, we may allow considering two types of information events in the same day, for example good news in the morning and bad news in the afternoon. For stocks with frequent information events or high values of α, the likelihood function may treat these arrival rates as noise trades. These concerns motivate us to consider two or three periods within each trading day.

4.3.1 General Findings

We analyze whether information events, news type, informed arrival rates and uninformed arrival rates are the same for the two periods over our sample period before comparing PINs of family-controlled and widely-held firms. We term the first half (before 1:00 pm) and second half (after 1:00 pm) of trading days as morning and afternoon respectively for convenience. At first, we analyze family-controlled firms.

It is obvious form Table 4.4 on the next page that arrival rates of both noise traders and informed traders differ across morning and afternoon sessions. For at least 25 firms, null hypotheses of equal rates of informed and uninformed traders are strongly rejected by large likelihood ratio test statistics. We find strong evidence in favour of Hypotheses 4 and 5. This suggests that the intensity parameter λ in the Poisson process changes over time. Since this is not valid for homogeneous Poisson processes, we are motivated to segregate each trading day into several periods. This allows us to get constant rate parameters within each period, but it allows the rate to change between periods. This particular statistical finding casts serious doubt on the results presented in Table 4.3 and, more generally on studies that consider whole trading days as independent event periods.

The joint hypothesis of equal information event and types of information event probabilities ($\alpha_M = \alpha_A$, $\delta_M = \delta_A$) is found to be significantly different for 45% of family-

Table 4.4: Test of Similar Parameters across Two Periods for Individual Family-Controlled Firms

Family-Controlled Firms						
Firm Symbol	**Null Hypotheses**					
	$\alpha_M = \alpha_A$	$\delta_M = \delta_A$	$\alpha_M = \alpha_A$, $\delta_M = \delta_A$	$\varepsilon_M = \varepsilon_A$	$\mu_M = \mu_A$	$\alpha_M = \alpha_A$, $\delta_M = \delta_A$, $\varepsilon_M = \varepsilon_A$, $\varepsilon_M = \varepsilon_A$
ABY	***		***	***	***	***
AGT				***	***	***
BVF				***	***	***
BPO				***	***	***
CFK	*			***	***	***
GIB				***	***	***
FLI				**		*
CBJ				***	***	***
CWG	***		***		***	**
CLS		**	**	***	***	***
CEF	***		**	***	***	***
CJR	***	***	***	***		**
DTC	**		**	***	***	***
FFH				***	***	***
FS				***		***
GG		**	*	***	***	***
HBG				***	***	***
LGF		***	**	***	***	***
MIM	***		***	***	***	***
MGA				***	***	***
MNG				***	***	***
PAL				***	***	***
OPY	***		***	**	***	***
PPK	***	**	*		***	**
IQW	***	*	***	***		**
RIC	***	***	***	***	***	***
RG				***	***	***
SJR				***	***	***
TOC				***	***	***

*, ** and *** represent significance level at 10%, 5% and 1% level respectively. Subscripts $_M$ and $_A$ represent periods before and after 1:00 pm of trading days. We use the LR test statistic to test whether the restrictions are in fact true. For large LR test statistics, we reject the null hypotheses. We reject $\alpha_M = \alpha_A$ for 38% of firms at 10%, $\delta_M = \delta_A$ for 24% of firms at 10%, $\varepsilon_M = \varepsilon_A$ for 93% of firms at 5% and $\mu_M = \mu_A$ for 86% of firms at 10%. We also reject the joint hypothesis of all restrictions for 97% of firms at 5% level. For 45% of firms, information event and information type are found to be different for morning and afternoon periods at 10% level. Every firm has 1,000 trading periods for the maximum likelihood estimation.

controlled firms. This finding is consistent with information events occurring only at the beginning of the trading day. If this is indeed the case, the rejection of similar informed trading rates in the morning and afternoon sessions is not surprising considering the market efficiency doctrine. However, we also find enough evidence to reject similar trade arrival rates of uninformed traders for 93% of family-controlled firms for the morning and afternoon sessions.[26] In addition, we find similar level of information events (α) for approximately 62% of family-controlled firms. Since similar level of information events are expected only if information event occurs within the trading day, we find strong evidence to support Hypothesis 3 that information events may occur more than once per day. To analyze this hypothesis formally, we directly test whether α_M and α_A are greater than zero. We present the results in Table A4.1 of Appendix 4. For all family-controlled and widely-held firms, we reject the null hypothesis that $\alpha = 0$ at 1% significance level.[27] A simple counter explanation of these findings would be that our results are sample

Table 4.5: Test of Similar Parameters across Two Periods for Individual Widely-Held Firms

Widely-Held Firms						
Firm Symbol	**Null Hypotheses**					
	$\alpha_M = \alpha_A$	$\delta_M = \delta_A$	$\alpha_M = \alpha_A$, $\delta_M = \delta_A$	$\varepsilon_M = \varepsilon_A$	$\mu_M = \mu_A$	$\alpha_M = \alpha_A$, $\delta_M = \delta_A$, $\varepsilon_M = \varepsilon_A$, $\varepsilon_M = \varepsilon_A$
AZK					***	**
BMO				***	***	***
BNS				***	***	***
BGO				***	***	***
BEL	**	***	***	***	***	***
CGT				***	***	***
HCH	***	***	***	***	***	***
CCJ				***	***	***

[26] Since we divided the trade day into two periods that have different lengths, we perform a similar maximum likelihood procedure by putting appropriate weights to those sessions. The three left most columns in Table 4.4 and 4.5 consider appropriate weights to conduct the LR test.
[27] We also test similar hypothesis for one- and three-periods. Results are presented in Table A4.2 and A4.3 of Appendix 4.

CNQ				***	***	***
CM	***		***	**		**
CNI				***	***	***
CP	**		*	***	***	***
KRY					***	**
EGO				***	***	***
ENB				***		***
ERF	***	***	***	***	***	***
EENC		***	***	***	***	***
FHR				***	***	***
GRS				***	***	***
GSS	**		**	***	***	***
GBN				***	***	***
IAG	**		*	***	***	***
IMO				**	***	***
N				***		**
IDR				***	***	***
IPS				***	***	***
KFS	**		**		*	*
MFC				***	***	***
MRB				***	***	***
NCX		*		***	***	***
NXG				***	***	***
PMU				***	***	***
PTF	***	***	***	***	***	***
PDG				***	***	***
PVX	***	***	***	***	***	***
RY		**	**	***	***	***
SLF				***	***	***
SU				***	***	***
TU	*			***	***	***
TLM				***	***	***
TAC				***	***	***
TRP	*					
TGA	*			***	***	***
ZL		***	**	***	***	***

*, ** and *** represent significance level at 10%, 5% and 1% level respectively. Subscripts $_M$ and $_A$ represent periods before and after 1:00 pm of a trading day. We use the LR test statistic to test whether the restrictions are in fact true. For large LR test statistics, we reject the null hypotheses. We reject $\alpha_M = \alpha_A$ for 30% of firms at 10%, $\delta_M = \delta_A$ for 20% of firms at 10%, $\varepsilon_M = \varepsilon_A$ for 91% of firms at 1% and $\mu_M = \mu_A$ for 88% of firms at 5%. For 30% of firms, information event and information type are found to be different for morning and afternoon periods at 10% level. We also reject the joint hypothesis of all restrictions for 95% of firms at 1% level. Every firm has 1,000 trading periods for maximum likelihood estimation.

specific. Therefore, we analyze 44 widely-held firms, the results of which are presented in Table 4.5.

Needless to say, our findings of widely-held firms in Table 4.5 confirm that our results of the family-controlled firms are not sample specific. Arrival rates of informed and uninformed traders are significantly different for 88% and 91% of firms respectively across morning and afternoon sessions. We also reject $\alpha_M = \alpha_A$ for 30% of the widely-held firms. This means 70% of the widely-held firms have statistically similar probability of information events for morning and afternoon sessions. For the same reasons discussed earlier, we reject Hypothesis 3, i.e. information events occur only at the beginning of the day, for 70% of widely-held firms. The joint hypothesis considering all restrictions is rejected for 43 out of 44 firms and therefore, presents strong evidence that assumptions together are not empirically valid to estimate parameters in Easley et al (1996a, 1996b). These findings confirm our suspicion about the findings of Table 4.3 and provide a basis to consider two periods within every trading day to estimate PINs of different firms. Based on this explanation, we now turn to comparing PINs of family-controlled firms to those of widely-held firms.

4.3.2 Family-Controlled Firms versus Widely-Held Firms

Tables A5.1 and A5.2 of Appendix 5 contain estimated PINs of family-controlled and widely-held firms considering two periods per trading day. Before analyzing PIN of family-controlled and widely-held firms, we present the summary statistics of the different parameters in Table 4.6.

One of the important observations is that both informed and uninformed trader arrival rates are higher for widely-held firms. One explanation for this is that widely-held firms are far greater in size and therefore have higher trading volume than family-controlled firms. Another potential explanation follows the idea and finding of Jiang and

Table 4.6: Descriptive Statistics of Parameters (Two Periods)

Statistics	Morning Session		Afternoon Session	
	Family-controlled	**Widely-held**	**Family-controlled**	**Widely-held**
Alpha (α)				
Mean	0.299	0.264	0.317	0.279
Standard Deviation	0.218	0.131	0.213	0.141
Epsilon (ε)				
Mean	101.105	172.278	84.941	133.798
Standard Deviation	139.600	185.286	108.848	138.818
Mu (μ)				
Mean	127.104	215.373	104.865	167.024
Standard Deviation	138.954	190.000	114.786	141.797
Percentage of Informed Traders (conditional on α)	38.883	38.515	38.435	38.495

We calculate the percentage of informed trader by dividing the average of informed traders by the sum of the average of informed and average of uninformed traders.

Kim (2005). Widely-held firms have large institutional shareholding and therefore are covered by more analysts. As a result, those stocks are more actively traded. Also important to note is that the percentage of informed traders is very similar for family-controlled and widely-held firms. Another interesting observation of Table 4.6 is that substantially more informed trading occurs in the morning session. This may be the consequence of heavy trading induced by the market clearing at the beginning of the trading day. For most stocks, we observe a U-shaped trading pattern that is tilted to the left (see Figure 4.1 and 4.2 of Section 4.4).

For both morning and afternoon sessions, the market maker perceives on average a higher probability of information events occurring, α, for family-controlled firms. In addition, α is higher in the afternoon session for both samples. If information events occur only at the beginning of the day, we expect the market maker to maintain a lower α for sessions that start considerably after the beginning the day. As a competitive market marker, he should recognize the occurrence of any information event soon after the trade begins. On the other hand, informed traders have to trade profitably before the market maker realizes their presence. These arguments support perceiving a lower probability of information events for afternoon sessions if the assumption that information events occur only at the beginning of the day is true. The higher α in afternoon sessions (along with the results in Appendix 4, which is based on tests that formally set $\alpha = 0$) provides considerable evidence in favour of Hypothesis 3 that information events may occur more than once per day.

Now we test whether the equality of similar PINs for family-controlled and widely-held firms holds, the results of which are presented in Table 4.7 (basen on Appendix 5). We find consistent results from Table 4.6 and Table 4.7. Higher PIN_{FC} and PIN_{WH} of the afternoon sessions in Table 4.7 are direct consequences of higher level of α_F in Table 4.6. This is consistent with the comparative analysis described in the literature review section.

We outlined in the literature review section that individuals or families as controlling shareholders are better informed. Since the market maker losses by trading with them, asymmetric information cost (and therefore the PIN) of family-controlled firms is expected to be higher than that of widely-held firms. However, we find the average PIN of widely-held firms to be higher than the average PIN of family-controlled firms for both ways of PIN calculation. In addition, there is enough evidence at the 5% significance level to reject the null hypothesis that PIN_{FC} and PIN_{WH} are similar as far as the morning session is concerned. This implies significantly lower PIN_{FC} than PIN_{WH} in the morning session, a fact that provides evidence against Hypothesis 2. It should be mentioned that the exact distributions of the estimated parameters, which are used to calculate

Table 4.7: Test of Equality of PINs of Family-Controlled and Widely-Held Firms (Two Periods)

	PIN_M: Easley et al (1996b)	Modified PIN_M	PIN_A: Easley et al (1996b)	Modified PIN_A
Family-Controlled Firms				
Mean	0.122	0.080	0.130	0.086
Standard Deviation	0.056	0.036	0.060	0.037
Sample size	29	29	29	29
Widely-Held Firms				
Mean	0.149	0.098	0.155	0.101
Standard Deviation	0.044	0.029	0.050	0.034
Sample Size	44	44	44	44
Hypothesis testing		***PIN_{FC} = PIN_{WH}***		
Z test statistic	2.215**	2.340***	1.826**	1.772**
Mann-Whitney Z	2.108**	2.255**	1.860**	1.420

*** and ** represent significance at 1% and 5% level respectively. PIN_M and PIN_A refer to the PIN of the morning session and afternoon session respectively.

PIN, are unknown. In addition, sample size of family-controlled firms is marginal. Consequently, we use the Mann-Whitney Z test. Both statistics for the morning session improve when the modified PIN is calculated. However, we cannot reject the null hypothesis of PIN_{FC} = PIN_{WH} for low Mann-Whitney Z statistic when afternoon session is considered. In addition, test statistics for the modified PIN for the afternoon session are lower than PIN calculation of Easley et al (1996b). Is the modified PIN significantly different from PIN calculated in Easley et al (1996b)? We investigate this question in more detail shortly. What we find from this section is that there is strong evidence to reject Hypothesis 2 for both sessions.

Our findings are quite interesting. To the best of our knowledge, no previous studies has considered multiple periods within trading days for the likelihood estimation. We find evidence in favour of multiple information-event occurrences within trading days. In addition, we find PIN_{FC} to be significantly lower than PIN_{WH} in the morning session only. Is a very low PIN_{FC} in the morning session driving our results? In an attempt to reconcile the confounding results and provide an economic explanation to the findings of Table 4.7, we analyze whether the PINs of our whole sample and individual samples are different across different sessions in Table 4.8.

Table 4.8: Test of Equality of PINs across Two Periods

Hypothesis testing	**$PIN_M = PIN_A$**	
	***t* statistic**	**Wilcoxon Z**
PIN: Easley et al (1996b)		
Total sample (73 firms)	-3.649***	-3.054***
Family-controlled firms	-3.618***	-3.038***
Widely-held firms	-2.170**	-1.575
Modified PIN		
Total sample (73 firms)	-2.978***	-2.422***
Family-controlled firms	-3.449***	-2.800***
Widely-held firms	-1.414	-0.794

*** and ** represent significance at 1% and 5% respectively. *t* statistics are based on matched samples and has (n-1) degrees of freedom. *t* statistic assumes population distribution of the sample differences, here ($PIN_M – PIN_A$), to be normal. Since this may not be true, we use the distribution-free Wilcoxon test statistic.

Low test statistics confirm that the Bayesian market maker does not form significantly different PINs for the morning and afternoon sessions for widely-held firms, but family-controlled firms do have significantly different PINs for morning and afternoon. The magnitude of the difference is strong enough to reject the null hypothesis of similar PINs across different sessions for the whole sample. This essentially helps us explain our earlier finding about why the PIN_{FC} is significantly lower than the PIN_{WH} for the morning session only. Based on the descriptive statistics of Table 4.7 and test statistics of Table 4.8, we conclude that the market maker maintains a very low PIN for family-controlled firms in the morning session only. In fact, this is causing the PIN_{FC} to be lower than PIN_{WH}. But, why does the market maker perceive very low PIN_{FC} for the morning session? Though we do not attempt to analyze this issue completely, our findings on α, ε and μ, outlined in Table 4.9, may explain this to some extent.

Table 4.9: Test of Equality of Parameters across Two Periods for Samples

Hypotheses	Family-controlled firms		Widely-held firms	
	***t* statistics**	**Wilcoxon Z**	***t* statistics**	**Wilcoxon Z**
$\alpha_M = \alpha_A$	-2.289**	-1.890**	-1.363	-0.507
$\varepsilon_M = \varepsilon_A$	2.428***	-4.076***	5.015***	-5.777***
$\mu_M = \mu_A$	3.843***	-3.471***	5.803***	-5.112***

*** and ** represent significance level at 1%, 5% and 10% respectively. The critical value of 1.890 is 2.94%.

For morning and afternoon sessions, the market maker perceives significantly different arrival rates of informed and uninformed trading for both family-controlled and widely-held firms. However, he perceives different probabilities of information events for two sessions for family-controlled firms only. From Table 4.6, we also find the probability of information events, α, to be lower in the morning session for both types of firms. Since the market maker increases the α for the afternoon session, we can strongly infer that α_M is significantly lower than α_A for family-controlled firms. This fact may cause the market marker to form significantly lower PIN_M of the family-controlled firms in the morning session.

In short, the statistical analyses imply a significantly lower α_M, probability of information events in the morning session, for family-controlled firms only. This causes the PIN of family-controlled firms in the morning session to be very low. We also claim that this fact may in turn cause the PIN_M to be lower than the PIN_A for family-controlled firms.

4.3.3 PIN of Easley et al (1996b) Versus Modified PIN

We have used both ways of PIN calculation in previous sections of this chapter. Do different PIN calculation methods really matter in empirical research? Since we do not expect to get boundary values of α for most of the stocks, we expect different numerical values for different PIN calculation methods. More specifically, we expect the modified PIN to be lower than the PIN developed by Easley et al (1996b).

Table 4.10: Test of Equality of Different PIN Calculations

Hypothesis Testing	**PIN of Easley et al (1996b) – Modified PIN = 0**	
	***t* statistic**	**Wilcoxon Z**
Morning Session	16.445***	-7.374***
Afternoon Session	15.174***	-7.374***

*** represents significance at 1% level. *t* statistics are based on the difference of matched pairs and since this assumes population distribution of the sample differences to be normal, we use the Wilcoxon non-parametric test. This test is based on the ranking of non-zero differences of two matched samples. We exclude one firm for which we find no difference between PIN of Easley et al (1996b) and modified PIN.

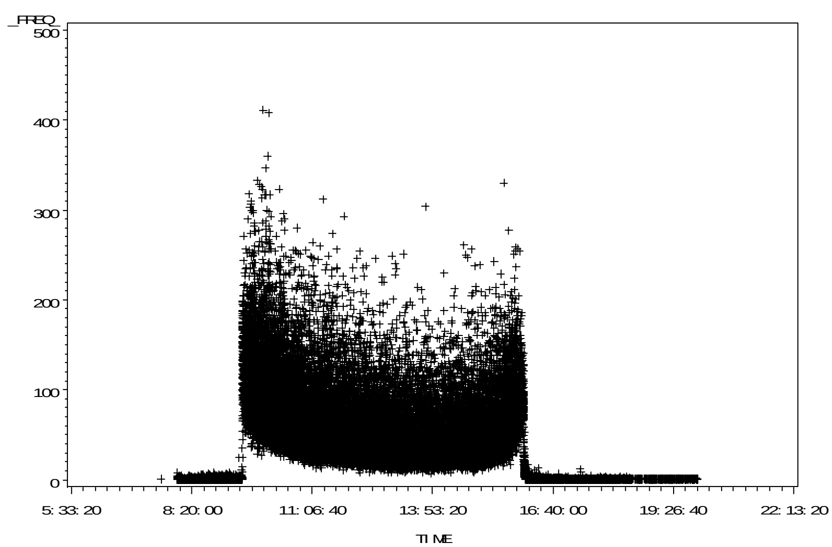
Table 4.10 compares the difference between the two methods of PIN calculation. We find that the PIN of Easley et al (1996b) is significantly lower than the modified one. Both test statistics provide enough evidence to reject the null at the 1% significance level (note that we find boundary values of α for one out of all family-controlled and widely-held firms). We confirm Hypothesis 6 that the modified PIN is less than the PIN developed by Easley et al (1996b). Since PIN has many empirical implications, e.g. its inclusion to the Fama-French three factor model in Easley et al (2002), we urge further research with our proposed formulation of PIN.

4.4 Three periods per day

In the previous section, we have presented strong evidence in favour of different rates of uninformed and informed traders across morning and afternoon sessions. Lee and Ready (1991) report a higher level of trading frequency before 11:00 am and after 2:30 pm. We also observe similar trends in trading frequency for most of our sample firms, (see Figures 4.1 and 4.2).

Figures 4.1 and 4.2 are consistent with previous literature that trading frequencies of stocks follow a U-shaped curve. From the graphs, we find that trading patterns are higher during the first and last hours. This suggests that trader arrival rates, ε and μ, should be different during the beginning and end of the day compared to the middle.

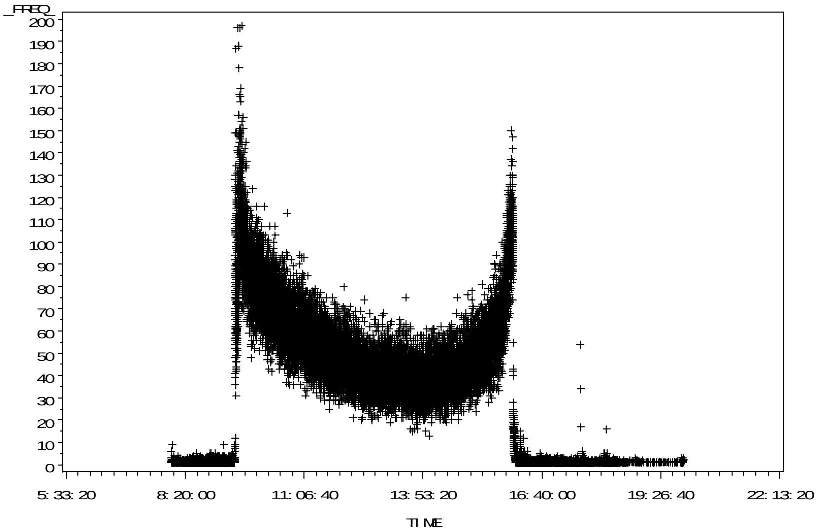
Figure 4.1: Frequency of Trading of BGO Stocks during Operational Hours



This graph depicts the trading pattern of Bema Gold Corporation (BGO), the most frequently traded widely-held company of our sample.

Therefore we separate each trading day into three event periods and analyze whether 1) the probabilities of information events (α) of different sessions are similar and 2) the PIN_{FC} is higher than the PIN_{WH} across different sessions.

Figure 4.2: Frequency of Trading of GG Stocks during Operational Hours



This graph depicts the trading pattern of Goldcorp Inc. (GC), the most frequently traded family-controlled company of our sample.

4.4.1 General Findings

Considering the study of Lee and Ready (1991), we segregate trading days into three periods – before 11:00 am, from 11:00 to 2:30 pm and after 2:30 pm. For convenience, we term these periods as first ($_F$), second ($_S$) and third ($_T$) session respectively. In this section, we use the Likelihood Ratio (LR) test to analyze whether the probabilities of α are similar across different sessions for every individual firms of our sample. We present the results of family-controlled firms first in Table 4.11.

For 59% of family-controlled firms, we cannot reject the null hypothesis that probabilities of information events across first and second sessions are similar. This goes up to 76% when we consider second and third sessions in the null hypothesis. Our results present strong evidence in favour of similar probability of information events across different sessions within trading days for most family-controlled firms. Since similar probability of information events is expected if information events occur more than once in a day, we find strong evidence in favour of Hypothesis 3. Based on these findings, we

Table 4.11: Test of Similar α across Three Periods for Individual Family-Controlled Firms

Family-Controlled Firms				
Firm Symbols	*Null Hypotheses*			
	$\alpha_F = \alpha_S$	$\alpha_S = \alpha_T$	$\alpha_F = \alpha_T$	$\alpha_F = \alpha_S = \alpha_T$
ABY			**	
AGT	***	*		**
BVF				
BPO				
CFK				
GIB			**	*
FLI	***	***	***	***
CBJ				
CWG				
CLS	***	*	*	***
CEF	***		***	***
CJR			**	*
DTC		*	**	*
FFH	***			***
FS	*		**	*
GG				
HBG	**		*	*
LGF	***		***	***
MIM		***	***	***
MGA				
MNG		**		*
PAL			*	
OPY	***		***	***
PPK				
IQW			*	
RIC	***	***	***	
RG	**			*
SJR	**		**	**
TOC				

***, ** and * represent significance at 1%, 5% and 10% level. Subscripts $_F$, $_S$ and $_T$ refers to the first, second and third sessions of a trading day. We use the LR test statistic to test whether the restrictions are in fact true. For large LR test statistics, we reject the null hypotheses. We reject $\alpha_F = \alpha_S$ for 41% of firms, $\alpha_S = \alpha_T$ for 24% of firms and the joint hypothesis for 55% of firms at 10% significance level. Every firm has 1,500 trading periods for the maximum likelihood estimation.

conclude that the market maker perceives different trading frequencies to imply different trading periods for most of the family-controlled stocks. Are the results specific to family-controlled firms?

The findings of widely-held firms in Table 4.12 are consistent with those for family-controlled firms. For 52% of widely-held firms, we find similar α across first and second sessions whereas we find similar α for 68% of widely-held across second and third session. Again, we do not expect similar probability of information events for sessions that start considerably after the beginning of the trading day. These findings therefore confirm our suspicion about findings considering one period per day. In addition, there may be a need to reconcile how many periods per day should be considered for empirical analysis. However, before making any conclusion on that issue, we compare the PINs of different samples.

4.4.2 Family-Controlled Firms versus Widely-Held Firms

We test whether the PIN of family-controlled firms is higher than the PIN of widely-held firms across first, second and third sessions.

From Table 4.13, we find all PINs of family-controlled firms to be higher than those of widely-held firms except the average modified PIN in the first session. However, the market maker does not observe a significantly higher PIN for family-controlled then

Table 4.12: Test of Similar α across Three Periods for Individual Widely-Held Firms

	Widely-Held Firms			
Firm	Null Hypotheses			
Symbols	$\alpha_F = \alpha_S$	$\alpha_S = \alpha_T$	$\alpha_F = \alpha_T$	$\alpha_F = \alpha_S = \alpha_T$
AZK	***	***	***	
BMO				
BNS				
BGO			**	*

BEL	***	**	***	***
CGT		***	***	***
HCH	***		***	***
CCJ		**		*
CNQ				
CM	***		***	***
CNI		*		
CP	**		**	**
KRY	***			**
EGO				
ENB				
ERF	***	***	***	***
EENC		*	**	*
FHR	**			*
GRS	***		***	***
GSS	**	**	*	*
GBN				
IAG	***		***	***
IMO		**	**	**
N	*			
IDR				
IPS				
KFS	***		**	***
MFC	**	**		**
MRB				
NCX				
NXG				
PMU		*	***	***
PTF	***	*	***	***
PDG				
PVX	***		***	***
RY			**	*
SLF	**			
SU	**		*	
TU		**		*
TLM				
TAC	***	***	***	***
TRP				
TGA	*		***	***
ZL	*			

***, ** and * represent significance at 1%, 5% and 10% level. Subscripts $_{F}$, $_{S}$ and $_{T}$ refers to first, second and third sessions of trading days. We use the LR test statistic to test whether the restrictions are in fact true. For large LR test statistics, we reject the null hypotheses. We reject $\alpha_F = \alpha_S$ for 48% of firms, $\alpha_S = \alpha_T$ for 32% of firms and the joint hypothesis for 55% of firms at 10% significance level. Every firm has 1,500 trading periods for the maximum likelihood estimation.

Table 4.13: Test of Equality of PINs of Family-Controlled and Widely-Held Firms (Three Periods)

Statistics	PIN: Easley et al (1996b)			Modified PIN		
	1st session	2nd session	3rd session	1st session	2nd session	3rd session
Family-Controlled						
Mean	0.192	0.192	0.199	0.102	0.110	0.109
Std. dev.	0.109	0.091	0.110	0.036	0.030	0.031
Size	29	29	29	29	29	29
Widely-Held						
Mean	0.178	0.173	0.176	0.106	0.108	0.107
Std. dev.	0.089	0.074	0.081	0.40	0.030	0.035
Size	44	44	44	44	44	44
Hypothesis testing: **$PIN_{FC} = PIN_{WH}$**						
Z statistic	0.656	0.920	0.950	-0.547	0.296	0.355
Mann-Whitney Z	0.417	-0.124	-0.034	0.868	-0.068	-0.349

We test the null hypothesis that PIN of family-controlled firm is equal to PIN of widely-held for every session. No test statistic is found significant at 5% level.

that for widely-held firms for any session. Both the Z statistics (based on different sample sizes) and the Mann-Whitney Z statistics are low enough to present consistent results. Based on this evidence, we reject Hypothesis 2 that the PIN_{FC} is higher than the PIN_{WH}.

Though the findings of the present and previous sections are not as expected, they are at least consistent. Separating the trading days into two and three sessions becomes the crucial factor in determining whether average PIN_{FC} is higher or lower (not statistically) than PIN_{WH}. However, it is clear that the assumptions of 1) constant arrival rates of informed and uninformed traders throughout the day and 2) information event occurrence only at the beginning of the day are not valid in empirical analysis.

As in the previous section, we investigate whether PINs of individual samples and whole sample are similar across different sessions in Table 4.14. In this analysis, we have first, second and third sessions for every type of sample firms. We use the Kruskal-Wallis one-way analysis of variance to test whether the three distributions, i.e. distributions for the first, second and third sessions, of PINs of any sample group is identical.

Table 4.14: Test of Equality of PINs across Three Periods

Hypothesis testing: $\mathbf{PIN_F = PIN_S = PIN_T}$		
Statistic	**PIN: Easley et al (1996b)**	**Modified PIN**
All firms		
Kruskal-Wallis test statistic	0.208	2.293
Widely-held firms		
Kruskal-Wallis test statistic	0.084	0.422
Family-controlled firms		
Kruskal-Wallis W	0.200	2.691

No test statistic is significant at 5% level. The Kruskal-Wallis test statistic follows χ^2 distribution with K – 1 degrees of freedom where K is the number of different samples. Here, we have three samples: first session ($_F$), second session ($_S$) and third session ($_T$).

For lower values of the Kruskal-Wallis test statistics, we cannot reject the hypothesis that distributions of PINs are the same across the three sessions for any of the individual samples, e.g. family-controlled firms. Of either sample group, the market maker does not form significantly different PINs for any session. We also test whether distributions of alpha during different sessions are similar.

We find from Table 4.15 that the market maker forms higher probabilities of information events for sessions that start later in the trading day. This finding is very similar to that of two-period analysis. However, differences among the probability distributions of information events are not found to be significant in Table 4.16. The Kruskal-Wallis test statistics are very low and therefore we do not reject the null hypothesis that distributions of alpha during different sessions are similar for any of our individual samples. Since the market maker perceives similar probability distributions on information events at the beginning of the first, second and third sessions, we do not the

Table 4.15: Descriptive Statistics of α (Three Periods)

	Family-controlled firms			Widely-held firms		
Statistics	**First**	**Second**	**Third**	**First**	**Second**	**Third**
Average	0.201	0.233	0.228	0.228	0.249	0.239
Standard Deviation	0.063	0.071	0.067	0.070	0.082	0.089

Table 4.16: Test of Equality of α across Three Periods

Hypothesis testing: $\alpha_F = \alpha_S = \alpha_T$			
	Family-controlled firms	***Widely-held firms***	***Total firms***
Kruskal-Wallis W	3.645	1.321	4.043

W is the Kruskal-Wallis test statistic. No test statistic is significant at 5% level. The Kruskal-Wallis test statistic follows χ^2 distribution with K – 1 degrees of freedom where K is the number of different samples. Here, we have three samples: first session ($_F$), second session ($_S$) and third session ($_T$).

reject Hypothesis 3. This finding along with the higher α in the second session provides strong evidence in favour of multiple periods within trading days. Our findings of Table 4.16 are consistent with those of Table 4.11 and 4.12. Based on the findings of Table 4.11 and 4.12, we could not reject the hypothesis of similar α across different sessions for most of the firms. Table 4.16 considers testing the same hypothesis for firms of specific samples, e.g. family-controlled. In both cases, we do not reject Hypothesis 3. Note that unlike in the two-periods-per-day analysis, we do not find significantly higher PIN or α for family-controlled firms in any session.

In a nutshell, our analysis considering three periods per day casts doubts on the findings of the one-period-per-day analysis. We conclude that the assumptions to estimate the parameters useful in calculating PIN are very strong. The Poisson arrival rates are not constant throughout the day. Therefore, to get precise estimates from the likelihood function, we should consider multiple periods within trading days.

We also find that PIN_{FC} is not significantly higher than PIN_{WH}. A competitive market maker would not have to maintain high spreads for stocks with relatively high numbers of noise traders and low numbers of informed traders since he is able to recoup losses from uninformed, noise traders with even a narrow spread. Furthermore, all of the corporate finance studies discussed in the literature review section consider abnormal profits by insiders. In this study, we analyze the adverse selection cost form the market maker's point of view. Since the market maker maintains the spread only to recoup his losses, our findings may not be entirely inconsistent with the existing literature.

4.4.3 Stability of Estimates

In the previous sub-sections we have estimated PINs based on one, two or three periods per day. An important issue is to investigate whether the estimated parameters are stable

Table 4.17: Stability of alpha and delta

	Family-controlled firms		Widely-held firms	
	Alpha	**Delta**	**Alpha**	**Delta**
One period/day	0.249	0.333	0.278	0.293
	(0.075)	(0.189)	(0.084)	(0.176)
Two periods/day				
Morning session	0.299	0.386	0.264	0.340
	(0.219)	(0.222)	(0.131)	(0.192)
Afternoon session	0.317	0.375	0.279	0.312
	(0.215)	(0.219)	(0.141)	(0.192)
Three periods/day				
First session	0.201	0.381	0.228	0.366
	(0.063)	(0.190)	(0.069)	(0.179)
Second session	0.233	0.377	0.249	0.317
	(0.072)	(0.188)	(0.082)	(0.173)
Third session	0.228	0.363	0.239	0.321
	(0.067)	(0.169)	(0.089)	(0.195)

in those analyses. We focus only on alpha (the probability of information event) and delta (the probability of bad news) since mu and epsilon (trade arrival rates of informed and uninformed traders respectively) are likely to differ.[28] The findings of this analysis are presented in Table 4.17. As we segregate trading days into different trading sessions, we get different numerical values of alpha and delta. We find that the parameter estimates of delta seem to fluctuate less than those of alpha. The stability of the parameter estimates in the two- and three-periods per day analyses strengths our investigation of multiple periods per trading day. However, a more formal analysis is warranted to verify how many sessions/trading day shall be considered in future studies.

4.5 Analyzing Firms with Change in Ownership Status

The findings of the previous sections empirically show how the market maker estimates the probability of informed trading for family-controlled and widely-held firms. In the three-periods-per-day analysis, we find that the average PIN_{FC} is higher (but not significantly) than the average PIN_{WH}, whereas in the two-periods-per-day analysis, we find the average PIN_{FC} to be (insignificantly) lower than the average PIN_{WH}. We also find that the market maker observes significantly lower probability of information events and therefore significantly lower PIN of family-controlled firms in the morning session. However, we did not find such results in the three-periods-per-day analysis.

In this section, we perform an event study about the event that a firm's ownership structure changes to analyze whether we are able to reach similar conclusions. We consider two periods per trading day to analyze this issue. To estimate the parameters accurately, we consider an event window of 30 days around the event day. We find 9 firms listed with NYSE or AMEX to have data in 2004-05 for at least 60 days both prior to and after the event window. For firms that change ownership status more than once,

[28] We have documented this in Table 4.4 and 4.5. We also present different epsilon and mu per period in Appendix 3. Results are similar in both cases.

we consider the first event only in our study as some firms re-change their ownership status very quickly.

4.5.1 General Findings

Before comparing the PINs of family-controlled and widely-held firms around the event period, we analyze how α, μ and ε change after such an event in Table 4.18. In particular, we compare whether estimates of these parameters change after altering the ownership structure. We present an example for clear understanding. We define Agnico-Eagle Mines Ltd. (AEM) as a family-controlled firm initially. However, it becomes widely-held on August 31, 2004. Since we consider an event window of 30 days, we perform our analysis on 60 trading days before August 16, 2004 and after June 14, 2004. In this case, we consider Agnico-Eagle Mines Ltd. family-controlled for 60 trading days before August 16, 2004 and widely-held for 60 trading days after June 14, 2004. Restrictions on parameters are tested individually and jointly in the likelihood estimation function. This enables us to directly perform the likelihood ratio test. For large values of LR test statistics, we reject the hypothesis (restriction). Rejecting hypotheses, or, in other words, finding significant changes in the rate of informed and uninformed traders and in the probability of information event of a firm suggest that the firm is *signalling* information to the market by altering its ownership status. How does the market maker react to such signals?

To the market maker, trading patterns of uninformed and informed traders significantly change for most of the firms. Change in the ownership structure certainly signals information to the market participants. Regardless of whether a firm changes its

Table 4.18: Test of Equality of Parameters across Two Periods (Event Study)

Firm Symbols	$\alpha_{Before}=\alpha_{After}$ (M) (1)	$\alpha_{Before}=\alpha_{After}$ (A) (2)	$\alpha_{Before}=\alpha_{After}$ (M), $\alpha_{Before}=\alpha_{After}$ (A) (1, 2)	$\varepsilon_{Before}=\varepsilon_{After}$ (M) (3)	$\varepsilon_{Before}=\varepsilon_{After}$ (A) (4)	$\varepsilon_{Before}=\varepsilon_{After}$ (M), $\varepsilon_{Before}=\varepsilon_{After}$ (A) (3, 4)	$\mu_{Before}=\mu_{After}$ (M) (5)	$\mu_{Before}=\mu_{After}$ (A) (6)	$\mu_{Before}=\mu_{After}$ (M); $\mu_{Before}=\mu_{After}$ (A) (5, 6)	(1, 2, 3, 4, 5, 6)
AEM				***	***	***	***	***	***	***
SNG				***	***	***	***	***	***	***
COT		***	***	***	***	***	***	***	***	***
GIL		*		***	***	***	**		**	***
GLG	***	***	***	***	***	***	*	***	***	***
MDG	***		**	***	***	***	***		***	***
MFN				***	***	***		***	***	***
POT	***		***		***	***	*	***	***	***
VGZ				***	***	***				***

M and A refer to morning and afternoon sessions. We reject (1) for 33.33% of firms at 1%, (2) for 33.33% at 10%, (3) for 88.89% of firms at 1%, (4) for all firms at 1%, (5) for 77.78% of firms at 1% and (6) for 66.66% of firms at 1% significance level. We reject the joint hypothesis (last column) for all firms at 1% significance level. It should be mentioned that every estimate with subscript $_{Before}$ and $_{After}$ are estimated with 60 trading days.

status from family-controlled to widely-held or vice versa, the average rates of both uninformed and informed trading increase after the event window (see the last row of Table A7.1 of Appendix 7). However, the market maker does not alter his probability of information event for most of the firms after such an event. We report Table 4.19 below to present information on the exact event date and how firms have changed their respective ownership.

Table 4.19: Firms with a Change in the Ownership Status

Firm Symbols	Exchange	Type of Change	Event Date
AEM	NYSE	Family-controlled to widely-held	August 31, 2004
SNG	AMEX	Widely-held to family-controlled	July 21, 2005
COT	NYSE	Family-controlled to widely-held	May 19, 2004
GIL	NYSE	Family-controlled to widely-held	June 30, 2005
GLG	NYSE	Widely-held to family-controlled	January 31, 2005
MDG	NYSE	Family-controlled to widely-held	April 30, 2004
MFN	AMEX	Family-controlled to widely-held	April 30, 2004
POT	NYSE	Widely-held to family-controlled	November 30, 2004
VGZ	AMEX	Family-controlled to widely-held	December 31, 2004

To identify the exact event date, we rely on the "Date of Event Which Requires Filing this Statement" section of 13D and 13G filings.

As stated earlier, we construct the family-controlled sample by considering family-controlled firms before and after the events. For example, we consider AEM before the event and SNG after the event in our family-controlled sample. We form the sample of widely-held firms in the same way. This enables us to compare the PIN_{FC} and PIN_{WH} around the reported event period.

4.5.2 Family-Controlled Firms Versus Widely-Held Firms

We find from the previous section that arrival rates of both informed and uninformed traders increase after a change in the ownership status. To see how the market maker revises the probability of informed trading, we compare the PIN of family-controlled to that of widely-held firms in Table 4.20.

Table 4.20: Testing Equality of PINs of Family-Controlled and Widely-Held Firms around the Event Period

Statistics	Morning Session		Afternoon Session	
	Family-Controlled	Widely-Held	Family-Controlled	Widely-Held
PIN: Easley et al (1996b)				
Mean	0.145	0.132	0.128	0.151
Standard Deviation	0.055	0.048	0.041	0.042
Modified PIN				
Mean	0.106	0.093	0.089	0.114
Standard Deviation	0.039	0.031	0.030	0.027

Hypothesis Testing:	$\boldsymbol{PIN_{FC} = PIN_{WH}}$	
	Morning Session	Afternoon Session
PIN: Easley et al (1996b)		
Wilcoxon T	16	8*
Modified PIN		
Wilcoxon T	16	4**

** and * represent significance at 5% and 10% respectively. The Wilcoxon T of 4 with sample size of 9 is significant at or above 2% level. Since sample size is less than 20, we use the Wilcoxon T instead of Z, the normal approximation.

For both calculations of PIN, the average PIN_{FC} is higher than the average PIN_{WH} in the morning session. However in the afternoon session, the average PIN_{FC} is lower than the average PIN_{WH}. It should be mentioned in this connection that we found the average PIN_{FC} to be lower than the average PIN_{WH} in both morning and afternoon sessions in the two-periods-per-day analysis. Though the hypothesis of equal PINs cannot be rejected for the morning session, there is enough evidence to reject it for the afternoon session. Therefore, PIN_{FC} is found to be significantly lower than PIN_{WH} in the afternoon session in this event study. This contrasts with our earlier two-periods-per-day finding that PIN of family-controlled is significantly lower than that of widely-held firms in the morning session. However, we still find PIN_{WH} to be higher, contrary to our Hypothesis 2. As earlier, we analyze the estimated parameters useful in the PIN calculation to see what is driving the PIN_{FC} in the afternoon session to be very low.

Table 4.21: Test of Equality of Parameters of Sample Firms around the Event Period

Statistics	Morning Session		Afternoon Session	
	Family-Controlled	Widely-Held	Family-Controlled	Widely-Held
Alpha (α)				
Mean	0.307	0.257	0.266	0.341
Standard Deviation	0.113	0.107	0.145	0.085
Epsilon (ε)				
Mean	154.468	172.251	136.472	130.705
Standard Deviation	119.696	127.482	98.687	92.648
Mu (μ)				
Mean	146.339	169.544	157.363	112.108
Standard Deviation	84.924	87.238	105.983	58.961

	Wilcoxon T	
Null Hypotheses	**Morning Session**	**Afternoon Session**
$\alpha_{FC} = \alpha_{WH}$	14	9*
$\varepsilon_{FC} = \varepsilon_{WH}$	18	18
$\mu_{FC} = \mu_{WH}$	17	10

* represent significance at 10% level. Since sample size is less than 20, we use the Wilcoxon T instead of Z, the normal approximation.

We test in Table 4.21 whether the estimates, which are useful in PIN calculation, of family-controlled firms are similar to those of widely-held firms. For high values of the Wilconxon T, we cannot reject all hypotheses except $\alpha_{FC} = \alpha_{WH}$ for the afternoon session. Since $\alpha_{FC} < \alpha_{WH}$ in the afternoon session, we conclude that the market maker infers a significantly lower probability of information events for family-controlled firms in that session. This may cause him to perceive significantly lower PIN_{FC} in the afternoon session. Since PIN of family-controlled firms is found to be significantly lower than that of widely-held firms, we reject Hypothesis 2 (that the PIN of family-controlled firms is higher than that of widely-held firms for the afternoon session).

4.6 Robustness Check

4.6.1 Constrained Maximum Likelihood Estimation

All of the results presented in previous sections consider unconstrained likelihood functions with Table 4.4, 4.5, 4.11, 4.12 and 4.18 as exceptions. If the findings of two- and three- periods-per-day are strong, we may expect to get similar results even with the constrained likelihood functions.

Since we are forcing all parameters – α, δ, μ and ε – in the afternoon to be equal to those of the morning in the two-period-per-analysis, our PIN estimates of the afternoon are expected to be equal to those of the morning. Therefore, we analyze PINs of family-controlled and widely-held firms for the morning session only in Table 4.22 in the previous page.

Like the unconstrained two-periods-per-day analysis, the constrained analysis in Table 4.22 shows that the average PIN_{FC} is lower than the average PIN_{WH}. High Z and Mann-Whitney test statistics confirm that the average PIN_{FC} is significantly lower than the average PIN_{WH} at 5% significance level. Based on this analysis, we reject Hypothesis 2.

In the three-period constrained likelihood function we are forcing the probability of information events occurring to be equal across three sessions only. As a result, PINs of three sessions are not likely to be the same since other parameters are not forced to be equal. We present the constrained analysis of three event periods per day in Table 4.23.

For the PIN calculation of Easley et al (1996b), we find the average PIN_{FC} to be higher than the average PIN_{WH}, a finding similar to that of unconstrained analysis. However for the modified PIN formulation, the average PIN_{FC} is slightly lower than the

Table 4.22: Test of Equality of PINs of Family-Controlled and Widely-Held Firms (Constrained)

Statistics	Family-controlled firms	Widely-held firms
PIN: Easley et al (1996b)		
Mean	0.128	0.151
Standard deviation	0.052	0.045
Sample size	29	44
Modified PIN		
Mean	0.084	0.099
Standard deviation	0.032	0.029
Sample size	29	44
Hypothesis testing	**$PIN_{FC} = PIN_{WH}$**	
	Z test	**Mann-Whitney Z**
PIN: Easley et al (1996b)	1.922**	2.040**
Modified PIN	1.918**	1.916**

** and *** represent significance levels at 5% and 1% respectively. Since the population distributions of parameters are unknown, we perform the Mann-Whitney non-parametric test.

Table 4.23: Test of Equality of PINs of Family-Controlled and Widely-Held Firms across Three Periods (Constrained)

Statistics	PIN: Easley et al (1996b)			Modified PIN		
	1st session	2nd session	3rd session	1st session	2nd session	3rd session
Family-Controlled						
Mean	0.204	0.187	0.194	0.110	0.104	0.106
Std. dev.	0.106	0.096	0.104	0.029	0.026	0.027
Size	29	29	29	29	29	29
Widely-Held						
Mean	0.183	0.169	0.178	0.111	0.105	0.108
Std. dev.	0.089	0.084	0.088	0.038	0.035	0.036
Size	44	44	44	44	44	44
Hypothesis testing: **$PIN_{FC} = PIN_{WH}$**						
Z statistic	0.877	0.804	0.660	-0.180	-0.066	-0.340
Mann-Whitney Z	-0.180	0.169	0.237	0.203	-0.124	0.349

We test the null hypothesis that PIN of family-controlled firm is equal to PIN of widely-held for every session. No test statistic is found significant at 5% level.

average PIN_{WH}. However, none of the test statistics are significant even at the 5% level. Considering three periods per day and assuming similar level of information events at the beginning of every period, we find that the market maker does not form significantly different PINs for family-controlled and widely-held firms. This confirms our findings on the three-period-per-day analysis of the previous section.

4.6.2 PIN of NASDAQ Firms

As mentioned before, we excluded 38 firms listed with NASDAQ only from the NYSE/ AMEX analysis for the apparent difference in the organized and OTC market setup. For the obvious importance, we perform a detailed study on these 38 NASDAQ listed firms in this section. 25 of 38 firms have data for the entire sample period. Of these 25 firms, 14 are identified as family-controlled firms whereas 11 are identified as widely-held firms. To define the ultimate ownership of a firm, we follow the same procedure as described in the Sample Construction, Section 3. We begin the investigation with the general findings of two- and three- periods per day analyses of NASDAQ-listed firms. In Table 4.24, we analyze whether the different restrictions on parameters, e.g. similar probability of information events, similar arrival rates of informed trading across different sessions etc., hold.

We find from Table 4.24 that in the two periods per day analysis, arrival rates of both informed and uninformed traders are different for over 90% of family-controlled and widely-held firms listed with NASDAQ. This finding shows that the Poisson arrival rates of informed and uninformed traders are not constant throughout the day. In addition, 71% and 73% of family-controlled and widely-held firms, respectively, do not have statistically different probability of information events. This supports the idea of considering multiple periods per day to estimate parameters from the likelihood estimation. The joint hypothesis of all restrictions is rejected for 96% of family-controlled and 100% of widely-held firms. These findings are very similar to those found in the two-period analysis of NYSE/AMEX listed firms and cast serious doubts on any empirical findings considering an entire day as an event period.

Is the three-period analysis of NASDAQ listed firms similar to that of NYSE/ AMEX listed firms? As earlier, we particularly investigate in Table 4.25 whether the probability of information events across two adjacent event periods are equal. We cannot reject $\alpha_F = \alpha_S$ and $\alpha_S = \alpha_T$ for 50% and 64% of family-controlled firms listed with NASD AQ respectively. Earlier in the NYSE/AMEX listed firms, we could not reject these restrictions for 59% and 76% of family-controlled firm respectively. The same restrictions, which were not rejected for 52% and 68% of NYSE/AMEX listed widely-held firms respectively, are now not rejected for 82% of widely-held firms listed with NASDAQ. Similar probability of information events across different sessions once again supports multiple event periods per trading day (Hypothesis 3).

The general findings of firms listed with NASDAQ are found to be similar to those of firms listed with NYSE/AMEX. Despite many differences in the organized and OTC market setup, we find arrival rates of both informed and uninformed traders to be different for different sessions for NASDAQ listed firms. In addition, similar probability of information events across adjacent sessions provides strong evidence to consider multiple event periods per day for the maximum likelihood estimation. These similar findings suggest we investigate whether PIN_{FC} is higher than PIN_{WH}. As usual, we perform the two-periods-per-day analysis at first.

Table 4.24: Test of Similar Parameters across Two Periods for Individual Family-Controlled and Widely-Held Firms (NASDAQ listed)

Firm Symbol	Null Hypotheses					
	$\alpha_M = \alpha_A$	$\delta_M = \delta_A$	$\alpha_M = \alpha_A$, $\delta_M = \delta_A$	$\varepsilon_M = \varepsilon_A$	$\mu_M = \mu_A$	$\alpha_M = \alpha_A$, $\delta_M = \delta_A$, $\varepsilon_M = \varepsilon_A$, $\varepsilon_M = \varepsilon_A$
Family-Controlled Firms						
BLD				***	***	***
CSL					*	
EXF	***		**	***		***
FSR				***	*	***
HYG	*			***	***	***
IMA	***		**	***	***	***
IVA			***	***	***	***
JCT				***		***
MER				***	***	***
NRM		*		***	***	***
RIM		*		***	***	***
STK				***	***	***
TES	**		*	***	***	***
ZIC				***	***	***
Widely-Held Firms						
BIO				***	***	***
CSP				***	***	***
DRA				***	***	***
FMT		***		***	***	***
HUM	***	***	***	***	***	***
MEO	***	**	**	***	***	***
PAA				***	***	***
SSP			***	***	***	***
TLC	*				***	***
VSG				***	**	***
WED				***	***	***

*, ** and *** represent significance level at 10%, 5% and 1% level respectively. Subscripts $_M$ and $_A$ represent periods before and after 1:00 pm of trading days. We use the LR test statistic to test whether the restrictions are in fact true. For large LR test statistics, we reject the null hypotheses. We reject $\alpha_M = \alpha_A$ for 29% and 27% of family-controlled and widely-held firms at 10%, $\delta_M = \delta_A$ for 14% and 27% of family-controlled and widely-held firms at 10%, $\varepsilon_M = \varepsilon_A$ for 93% and 91% of family-controlled and widely-held firms at 10% and $\mu_M = \mu_A$ for 86% and 100% of family-controlled and widely-held firms at 10%. We also reject the joint hypothesis of all restrictions for 96% and 100% of family-controlled and widely-held firms at 1% level. Every firm has 1,000 trading periods for the maximum likelihood estimation.

Table 4.25: Test of Similar α across Three Periods for Individual Family-Controlled Firms

Firm Symbols	Null Hypotheses			
	$\alpha_F = \alpha_S$	$\alpha_S = \alpha_T$	$\alpha_F = \alpha_T$	$\alpha_F = \alpha_S, \alpha_S = \alpha_T$
Family-Controlled Firms				
BLD	***	***		***
CSL				
EXF	**		***	***
FSR	***		***	***
HYG				
IMA	***	***		***
IVA			*	
JCT	**	***		***
MER	**	***		**
NRM				
RIM				
STK	***	*		***
TES				
ZIC				
Widely-Held Firms				
BIO				
CSP		***	**	***
DRA	***		***	***
FMT				
HUM	***		***	***
MEO				
PAA				
SSP				
TLC				
VSG		*		***
WED				

***, ** and * represent significance at 1%, 5% and 10% level. Subscripts $_F$, $_S$ and $_T$ refers to the first, second and third sessions of a trading day. We use the LR test statistic to test whether the restrictions are in fact true. For large LR test statistics, we reject the null hypotheses. We reject $\alpha_F = \alpha_S$ for 50% and 18% of family-controlled and widely-held firms, $\alpha_S = \alpha_T$ for 36% and 18% of family-controlled and widely-held firms and the joint hypothesis for 50% and 36% of family-controlled and widely-held firms at 10% significance level. Every firm has 1,500 trading periods for the maximum likelihood estimation.

Two main findings of the descriptive statistics of Table 4.26 are as follows: First, family-controlled firms listed with NASDAQ have a higher average PIN than widely-held firms. Note that earlier we found for NYSE/AMEX listed firms that the average

Table 4.26: PINs of Family-Controlled and Widely-Held Firms listed with NASDAQ (Two Periods)

	PIN_M: Easley et al (1996b)	**Modified PIN_M**	**PIN_A: Easley et al (1996b)**	**Modified PIN_A**
Family-Controlled Firms				
Mean	0.171	0.093	0.171	0.095
Standard Deviation	0.062	0.014	0.059	0.018
Sample size	14	14	14	14
Widely-Held Firms				
Mean	0.156	0.088	0.156	0.094
Standard Deviation	0.027	0.008	0.026	0.011
Sample Size	11	11	11	11
Hypothesis testing		***$PIN_{FC} = PIN_{WH}$***		
Mann-Whitney Z	-0.493	-1.533	-0.438	0

We test the null hypothesis that PIN of family-controlled firm is equal to PIN of widely-held for every session. No test statistic is found significant at 5% level.

PIN_{FC} is lower than the average PIN_{WH}. Second, the descriptive statistics of PIN_M and PIN_A are very similar. The Mann-Whitney Z test is performed to investigate whether this similarity is significant. The low values of test statistics mean that we cannot reject the equality of PINs of family-controlled and widely-held firms in morning and afternoon sessions. Therefore, we reject Hypothesis 2 that PIN_{FC} is higher than PIN_{WH}.

The two-periods-per-day analysis on NASDAQ listed firms strengthens most of our findings of NYSE/AMEX listed firms. This study on NASDAQ listed firms also warrants further research to analyze factors that cause the market maker in the NYSE/AMEX to form significantly lower PIN for family-controlled firms and multiple market makers in the NASDAQ to infer similar PINs for family-controlled and widely-held firms.

We now compare the PIN of family-controlled and widely-held firms listed with NASDAQ by considering three periods per trading day in Table 4.27. Like NYSE/AMEX listed family-controlled firms, NASDAQ family-controlled firms have

Table 4.27: PINs of Family-Controlled and Widely-Held Firms listed with NASDAQ (Three Periods)

Statistics	PIN: Easley et al (1996b)			Modified PIN		
	1st session	2nd session	3rd session	1st session	2nd session	3rd session
Family-Controlled						
Mean	0.220	0.218	0.220	0.099	0.111	0.106
Std. dev.	0.133	0.140	0.133	0.029	0.041	0.035
Size	14	14	14	14	14	14
Widely-Held						
Mean	0.189	0.174	0.180	0.093	0.098	0.099
Std. dev.	0.081	0.069	0.071	0.018	0.032	0.033
Size	11	11	11	11	11	11
Hypothesis testing: **PIN_{FC} = PIN_{WH}**						
Mann-Whitney Z	-0.219	-0.493	-0.383	-0.383	-0.712	-0.821

We test the null hypothesis that PIN of family-controlled firm is equal to PIN of widely-held for every session. No test statistic is found significant at 5% level.

higher PIN, on an average, than NASDAQ widely-held firms in the three periods per day analysis. However, the Mann-Whitney Z statistics are not high enough to reject the equality of PINs of family-controlled and widely-held firms. Based on this, we also reject Hypothesis 2, i.e. PIN_{FC} is higher than PIN_{WH}.

The findings of the three-periods-per-day analysis on NASDAQ listed firms are consistent with those on NYSE/AMEX listed firms. Though the average PIN_{FC} is higher than the average PIN_{WH}, they are not significantly higher.

4.7 Summary of the Findings

This chapter entails analysis of PIN by considering different numbers of periods per trading day. Based on the two periods per day analysis of NYSE/AMEX and NASDAQ listed firms, we find strong evidence in favour of different arrival rates of informed and uninformed traders. Graphs of trading frequency of frequently traded firms also confirm the idea of Lee and Ready (1991) that trading volume is higher in the first and last couple of hours of trading. We also find a higher alpha (α) at the beginning of afternoon session (1:00 pm) and second session (11:00 am) in the two- and three- period analyses respectfully. Since the probability of information events (α) is not expected to rise later on in the trading day if information events occur only once at the beginning, both two- and three- period analyses of NYSE/AMEX and NASDAQ listed firms establish strong support for the occurrence of multiple information events within trading days. These particular findings cast serious doubts on empirical results that consider the entire day as an event to estimate PIN from the likelihood function. This is one of the most important findings of this study.

Both two- and three- periods-per-day analyses provide evidence against Hypothesis 2, i.e. PIN_{FC} is higher than PIN_{WH}. The event study also reports strong evidence against the same hypothesis. In addition, we find PIN_{FC} to be significantly lower than PIN_{WH} in the morning session of the two-periods-per-day study and in the afternoon session of the event study. We find in both cases that the probability of information event (α) is the driving factor of such results. These findings are consistent with the existing literature for several reasons. First, the market maker only needs to maintain a narrow spread for firms with relatively high uninformed traders and low informed traders.[1] Second, the PIN, which is a function of the probability of an information event and the rate of informed and uninformed traders, has been used to capture the asymmetric information cost in this study. The PIN variable does not include order sizes and order book information, both of which are used by market makers in making inferences on information contents of incoming orders. Hence, PIN might be a poor proxy to capture the inferences made by market makers. Third, one of our limitations of this study is that we define a firm to be a family-controlled if anyone of the ultimate owners is found to be an individual or member of a family/group. We do not analyze whether that firm is controlled by two or more families. The main idea of Demsetz (1986), which is empirically supported by Fidrmuc (2006), is that concentrated ownership with less diversified portfolio encourages monitoring activities. If a firm is controlled by two or more families, the level of information asymmetry, and thereby PIN, may be very low as these families will act as monitors of one another, e.g. they may implement stringent rules on insider trading. The same situation will result if the controlling individual or family is found to be unrelated to the management. Forth, controlling shareholders may refrain from trading on inside information. Though corporate finance studies report abnormal returns by insiders, it is not clear what proportion of insiders actually trade on inside information.

We find results of two- and three-periods per day analyses to be inconsistent in that PIN_{FC} is found to be lower than PIN_{WH} in the two-periods-per-day analysis only. This warrants further research to reconcile how many periods to consider in the likelihood function developed by Easley et al (1996a, 1996b). Since information events

[1] It should be mentioned here that we found the ratio of informed traders to the total number of traders given an information event very similar (around 38.50%) for family-controlled and widely-held firms.

occur after sporadic intervals, its probability (α) is empirically found to maintain strong form of inequality ($0 < \alpha < 1$). As a result, the modified PIN is also found to be lower than the PIN developed by Easley et al (1996b). Since the PIN has been used extensively in research, we also recommend further research with our proposed formulation of PIN.

In conclusion, the findings of this chapter cast serious doubts on prevalent methodology and findings using PIN, and suggest further research to reconfirm existing results.

Chapter 5

Conclusions

5.1 Concluding Remarks

In this paper, we analyze the information asymmetry of two classes of firms, namely family-controlled and widely-held firms. Since a controlling person of a family-controlled firm holds substantial proportion at the cost of having a less diversified portfolio, he specializes his portfolio. Therefore, a controlling person/family/group is expected to have a higher level of inside information and make substantial abnormal profits. Knowing this, the market maker should maintain a higher spread for family-controlled firms than for firms with no controlling person/family/group. The PIN variable developed by Easley et al (1996a, 1996b) has been used to measure the level of information asymmetry in this study. We estimate the parameters from the likelihood function and use these estimates to calculate PINs of family-controlled and widely-held firms.

For a sample of Canadian-based publicly traded firms cross-listed with NYSE and AMEX, we find evidence in favour of a higher average spread for family-controlled firms (Hypothesis 1). However, we find statistically similar PINs for family-controlled and widely-held firms by considering one day as an event period and three event periods per trading day. However in the two-period analysis, we find significantly lower PINs for family-controlled firms for the morning session. We also perform an event study about the event that a firm's ownership structure changes and find statistically lower PINs for family-controlled firms for the afternoon session. Since we reach different conclusions on Hypothesis 2, which says the PIN of family-controlled firms is higher than that of widely-held firms, by considering different periods per trading day, we recommend further research to resolve this issue. Note that PIN is a function of the probability of information events and arrival rates of informed and uninformed traders. For the same number of informed traders, PIN of firm A may be substantially lower than that of firm B for relatively higher number of uninformed traders. In addition, PIN_{FC} may be lower than PIN_{WH} if family-controlled firms have more than one controlling shareholders. Furthermore, controlling shareholders may refrain from trading on inside information. Though several corporate finance studies find abnormal profits of insiders, it is not clear what proportion of the insiders actually trade. Similar percentages of informed traders of family-controlled and widely-held firms reported in the two-period analysis also support this idea. Another limitation of using the PIN variable is that it does not include order sizes and order book information, both of which are utilized by market makers in making inferences on information contents of incoming orders. From this perspective, the PIN variable may be a poor proxy for inferences made by market makers. Since we use the PIN variable in this study to measure information asymmetry, our results share similar limitations.

By considering several periods within a trading day, we test whether the assumptions that 1) information events may occur only at the beginning of the day and 2) constant arrival rates of informed and uninformed traders in the Poisson process hold. The two-period analysis strongly supports Hypotheses 4 and 5 that arrival rates of both uninformed and informed traders change over time within a trading day. Graphs of frequently traded stocks confirm this idea. In addition, our finding on similar probability of information events within trading days provides evidence in favour of more than one information event per day (Hypothesis 3). Based on these findings, we have doubts about any empirical PIN analysis that considers the entire day as an event period. We recommend research to re-evaluate the existing findings.

We also attempt to develop a different formulation of PIN based on the probability that the next arriving trader is informed. Based on our empirical findings, we fail to reject Hypothesis 6 that the modified PIN is less than the PIN defined by Easley et al (1996b). We also recommend further research with our formulation of PIN since this variable has been used extensively in finance literatures.

5.2 Limitations

This study has several limitations based on which future research can be performed. First, we consider family-controlled and widely-held firms cross-listed with NYSE, AMEX and NASDAQ only in this study. It is also important to analyze how the market maker perceives family-controlled and widely-held firms before cross listing with the U.S. exchanges.

Second, the sampling criterion of family-controlled firms has several limitations. We classify a firm as family-controlled if we were able to identify any individual or family members as a group to have controlling voting rights. However, it is possible that a single firm is controlled by many individuals or families. In addition, we do not attempt to see whether controlling members are related to the management. Fidrmuc et al (2006) and Demsetz (1986) note that corporations and families better perform the monitoring activity and therefore, if any of these cases turns out to be true for some of the family-controlled firms, then we expect a lower level of information asymmetry, and therefore

PIN, for the whole family-controlled sample. A further study to resolve this problem is definitely warranted.

Third, Easley et al (1996b) report information asymmetry across stocks with different trading frequency. Easley et al (2002) and Chiang and Venkatesh (1988) report higher level of information asymmetry for smaller firms. Therefore, a further study by considering different levels of trading frequency and firm size to sub-categorize our samples may also be conducted.

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Appendix 1
Table A1.1: Summary Statistics of Buys and Sells with Informed and Uninformed Trading

Family-controlled Firms

	Buys				Sells				epsilon	mu
	Min	Max	Avg	Std	Min	Max	Avg	Std		
ABY	38	760	210.808	110.171	21	850	176.704	87.292	177.344	195.849
AGT	5	356	58.624	47.329	4	364	54.224	41.266	53.774	90.566
BVF	194	6137	779.478	558.286	220	5269	718.592	514.628	618.083	531.478
BPO	3	787	228.298	103.559	20	531	154.268	79.937	169.935	167.407
CFK	0	450	55.440	80.136	0	352	49.288	65.964	60.038	166.881
GIB	3	370	37.006	31.375	4	240	35.438	24.265	35.119	57.517
FLI	1	109	20.758	15.728	1	181	21.284	17.504	19.955	37.657
CBJ	25	691	229.448	119.376	42	1344	231.664	133.600	213.292	233.366
CWG	0	98	3.508	6.545	0	22	3.278	3.713	2.071	12.184
CLS	234	3492	795.286	330.459	242	2985	660.686	276.539	649.101	401.225
CEF	42	750	152.830	84.821	15	676	107.418	67.940	116.854	166.103
CJR	0	41	4.616	5.791	0	37	4.494	4.756	3.125	10.140
DTC	22	755	126.144	79.168	11	503	97.570	63.098	103.053	126.903
FFH	9	1071	98.972	97.901	3	814	79.080	73.695	83.808	157.192
FS	40	2028	391.482	246.600	37	1633	296.978	189.446	306.330	351.654
GG	416	5462	1365.454	781.038	402	3809	1178.618	619.443	1000.865	745.152
HBG	3	429	48.144	36.495	1	246	39.994	28.734	39.837	59.615
LGF	55	3792	408.092	322.382	34	1774	325.556	235.487	316.120	352.276
MIM	8	884	113.592	87.240	14	786	111.384	76.141	104.681	129.957
MGA	115	1524	441.400	200.879	99	1166	359.072	167.995	358.435	301.918
MNG	15	1444	141.508	132.984	19	769	140.612	104.309	129.918	200.478
PAL	39	1064	250.744	171.012	33	1300	223.614	147.938	209.121	292.381
OPY	0	42	5.728	6.859	0	99	9.134	9.324	6.995	20.969
PPK	0	29	2.024	3.610	0	23	2.058	3.132	1.943	8.913
IQW	6	587	70.276	58.873	8	377	55.022	40.104	59.184	110.612
RIC	0	91	13.880	13.097	0	107	22.334	17.860	16.958	36.515
RG	2	503	98.878	79.404	1	723	89.596	77.020	93.315	148.136
SJR	27	604	141.158	83.708	7	587	136.666	90.718	133.972	172.836
TOC	7	241	69.016	34.713	7	202	62.338	30.929	61.027	59.904

Widely-held Firms

	Buys				Sells				epsilon	mu
	Min	Max	Avg	Std	Min	Max	Avg	Std		
AZK	0	310	22.732	34.503	0	188	18.638	19.429	20.423	109.712
BMO	13	295	70.314	33.883	6	262	61.546	30.984	62.689	66.097
BNS	6	218	55.824	33.136	0	191	37.820	26.901	44.057	65.710
BGO	183	11358	1590.446	1495.724	217	10707	1544.712	1439.375	993.543	858.593
BEL	0	651	66.470	74.722	0	881	57.610	69.191	58.698	114.179
CGT	0	278	27.406	25.617	0	248	24.168	23.507	27.034	71.963
HCH	0	219	2.990	10.332	0	46	3.628	4.280	1.973	7.596
CCJ	60	3264	803.664	631.774	46	2678	645.104	537.915	558.949	696.187
CNQ	90	3294	846.500	650.613	73	2809	663.858	544.044	548.238	741.470
CM	0	55	5.190	5.971	0	20	2.950	3.551	3.575	10.280

CNI	182	2013	674.720	286.430	169	1543	548.930	224.282	553.724	415.322
CP	65	1905	334.476	238.610	55	1614	279.850	187.896	273.397	331.587
KRY	28	2555	252.826	259.441	24	2232	234.620	229.332	208.016	378.375
EGO	15	2168	212.962	223.875	29	1549	178.734	182.002	154.258	235.259
ENB	3	1023	112.664	117.697	0	492	86.046	82.847	98.128	204.477
ERF	250	2112	571.910	264.767	111	3646	415.526	319.450	426.201	445.684
EENC	73	4277	430.256	422.563	27	4863	438.484	482.385	327.949	422.695
FHR	86	1623	384.366	198.866	65	1004	293.468	129.890	302.752	307.330
GRS	20	542	110.358	80.161	14	802	105.470	81.858	98.194	151.825
GSS	129	4960	822.816	578.377	139	4572	806.906	552.899	664.626	611.477
GBN	5	549	63.538	53.810	8	366	70.848	52.294	63.014	107.488
IAG	21	1536	158.000	111.384	27	673	137.850	86.528	134.320	160.393
IMO	35	682	159.432	93.859	8	590	114.268	76.075	124.958	163.496
N	0	4283	1368.550	550.019	356	4262	1158.838	482.618	1127.175	785.249
IDR	31	650	168.864	91.349	12	540	136.484	74.236	139.799	141.705
IPS	1	2156	349.258	324.605	2	1412	314.528	304.931	314.148	391.346
KFS	0	207	32.616	26.483	0	219	34.912	28.336	33.663	60.497
MFC	130	2207	440.212	177.249	172	2314	443.204	180.445	411.385	284.763
MRB	0	370	33.580	33.319	0	231	33.490	29.696	32.426	73.597
NCX	72	2196	489.000	335.484	56	1840	382.598	261.123	391.795	458.380
NXG	35	1505	256.828	212.439	40	1511	233.004	170.568	225.934	380.617
PMU	0	766	93.690	96.824	8	586	98.146	85.244	91.959	208.643
PTF	125	1636	461.406	220.862	53	2061	309.516	243.168	318.912	329.377
PDG	542	11927	1420.600	741.182	388	11056	1212.512	676.819	1163.842	745.332
PVX	163	3503	555.212	283.353	85	2618	331.728	257.915	343.158	375.439
RY	13	498	104.606	46.290	23	510	112.430	46.873	102.929	86.366
SLF	40	578	201.922	80.831	37	502	207.656	69.815	191.558	144.383
SU	406	5703	1613.022	1063.908	205	5375	1179.230	873.841	876.422	875.335
TU	1	1367	96.564	103.577	1	354	70.482	57.698	75.588	136.367
TLM	128	3947	783.420	515.298	105	2310	615.196	395.570	601.515	683.503
TAC	0	199	22.366	18.399	0	151	22.444	19.576	22.868	47.007
TRP	56	883	229.512	123.857	50	848	192.728	104.302	192.510	240.219
TGA	10	2580	229.228	208.817	9	2465	208.708	189.618	198.097	282.557
ZL	0	599	70.524	66.061	5	432	64.622	55.558	64.603	123.516

Appendix 2
One Period per Day Analysis of NYSE/AMEX Listed Firms

Table A2.1: PIN of Individual Family-Controlled Firms

Symbol	PIN (Easley et al 1996b)	Modified PIN
ABY	0.143	0.107
AGT	0.146	0.092
BVF	0.101	0.079
BPO	0.170	0.137
CFK	0.207	0.109
GIB	0.130	0.082
FLI	0.170	0.105
CBJ	0.133	0.099
CWG	0.051	0.014
CLS	0.106	0.091
CEF	0.162	0.113
CJR	0.294	0.159
DTC	0.144	0.104
FFH	0.151	0.092
FS	0.135	0.099
GG	0.103	0.083
HBG	0.178	0.124
LGF	0.150	0.114
MIM	0.126	0.089
MGA	0.120	0.096
MNG	0.148	0.098
PAL	0.169	0.120
OPY	0.382	0.125
PPK	0.456	0.188
IQW	0.127	0.075
RIC	0.201	0.121
RG	0.151	0.099
SJR	0.115	0.079
TOC	0.131	0.101

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$

Table A2.2: PIN of Individual Widely-Held Firms

Symbol	PIN (Easley et al 1996b)	Modified PIN
AZK	0.205	0.070
BMO	0.110	0.081
BNS	0.154	0.104
BGO	0.130	0.105
BEL	0.194	0.122
CGT	0.136	0.067
HCH	0.353	0.187
CCJ	0.203	0.157
CNQ	0.170	0.122
CM	0.459	0.264
CNI	0.131	0.109
CP	0.134	0.096
KRY	0.128	0.077
EGO	0.144	0.096
ENB	0.189	0.114
ERF	0.143	0.110
EENC	0.152	0.109
FHR	0.132	0.101
GRS	0.152	0.101
GSS	0.133	0.105
GBN	0.169	0.110
IAG	0.144	0.105
IMO	0.150	0.106
N	0.095	0.078
IDR	0.149	0.116
IPS	0.176	0.132
KFS	0.149	0.092
MFC	0.085	0.069
MRB	0.163	0.091
NCX	0.169	0.129
NXG	0.139	0.088
PMU	0.164	0.092
PTF	0.181	0.145
PDG	0.091	0.075
PVX	0.221	0.183
RY	0.087	0.067
SLF	0.098	0.079
SU	0.162	0.129
TU	0.231	0.158
TLM	0.164	0.125
TAC	0.137	0.078
TRP	0.148	0.107
TGA	0.169	0.119
ZL	0.166	0.102

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$

Appendix 3
Table A3.1: Test of Similar parameters across two periods

Significant at 10% (*), 5%(**) & 1%(***)

Family-controlled firms

Symbol	$\varepsilon_M = \varepsilon_A$	$\mu_M = \mu_A$
ABY	***	***
AGT	***	***
BVF	***	***
BPO	***	***
CFK	***	***
GIB	***	***
FLI	**	
CBJ	***	***
CWG		***
CLS	***	***
CEF	***	***
CJR	***	
DTC	***	***
FFH	***	***
FS	***	
GG	***	***
HBG	***	***
LGF	***	***
MIM	***	***
MGA	***	***
MNG	***	***
PAL	***	***
OPY	**	***
PPK		***
IQW	***	
RIC	***	***
RG	***	***
SJR	***	***
TOC	***	***

Widely-held firms

Symbol	$\varepsilon_M = \varepsilon_A$	$\mu_M = \mu_A$
AZK		***
BMO	***	***
BNS	***	***
BGO	***	***
BEL	***	***
CGT	***	***
HCH	***	***
CCJ	***	***
CNQ	***	***
CM	**	
CNI	***	***
CP	***	***
KRY		***
EGO	***	***
ENB	***	
ERF	***	***
EENC	***	***
FHR	***	***
GRS	***	***
GSS	***	***
GBN	***	***
IAG	***	***
IMO	**	***
N	***	
IDR	***	***
IPS	***	***
KFS		*
MFC	***	***
MRB	***	***
NCX	***	***
NXG	***	***
PMU	***	***
PTF	***	***
PDG	***	***
PVX	***	***
RY	***	***
SLF	***	***
SU	***	***
TU	***	***
TLM	***	***
TAC	***	***
TRP		
TGA	***	***

ZL	***	***

Note: We estimate the maximum likelihood by putting appropriate weights to the morning and afternoon sessions, i.e. 3.5 hours and 3 hours in this table.

Appendix 4

Table A4.1: Test of No Information Events (Two Periods)

Family-controlled Firms				Widely-held Firms			
Symbol	**α_M=0**	**α_A=0**	**α_M=α_A=0**	**Symbol**	**α_M=0**	**α_A=0**	**α_M=α_A=0**
ABY	***	***	***	CCJ	***	***	***
AGT	***	***	***	CNQ	***	***	***
BVF	***	***	***	CM	***	***	***
BPO	***	***	***	CNI	***	***	***
CFK	***	***	***	CP	***	***	***
GIB	***	***	***	KRY	***	***	***
FLI	***	***	***	EGO	***	***	***
CBJ	***	***	***	ENB	***	***	***
CWG	***	***	***	ERF	***	***	***
CLS	***	***	***	EENC	***	***	***
CEF	***	***	***	FHR	***	***	***
CJR	***	***	***	GRS	***	***	***
DTC	***	***	***	GSS	***	***	***
FFH	***	***	***	GBN	***	***	***
FS	***	***	***	IAG	***	***	***
GG	***	***	***	IMO	***	***	***
HBG	***	***	***	N	***	***	***
LGF	***	***	***	IDR	***	***	***
MIM	***	***	***	IPS	***	***	***
MGA	***	***	***	KFS	***	***	***
MNG	***	***	***	MFC	***	***	***
PAL	***	***	***	MRB	***	***	***
OPY	***	***	***	NCX	***	***	***
PPK	***	***	***	NXG	***	***	***
IQW	***	***	***	PMU	***	***	***
RIC	***	***	***	PTF	***	***	***
RG	***	***	***	PDG	***	***	***
SJR	***	***	***	PVX	***	***	***
TOC	***	***	***	RY	***	***	***
Widely-held Firms				SLF	***	***	***
AZK	***	***	***	SU	***	***	***
BMO	***	***	***	TU	***	***	***
BNS	***	***	***	TLM	***	***	***
BGO	***	***	***	TAC	***	***	***
BEL	***	***	***	TRP	***	***	***
CGT	***	***	***	TGA	***	***	***
HCH	***	***	***	ZL	***	***	***

Note: We use the LR test statistic to test the null hypothesis of no information events. *** and ** refer to 1% and 5% significance level.

Table A4.2: Test of No Information Events (One Period)

Significant at 10% (*), 5%(**) & 1%(***)			
Family-controlled Firms		Widely-held Firms	
Symbol	***α =0***	**Symbol**	***α=0***
ABY	***	CCJ	***
AGT	***	CNQ	***
BVF	***	CM	***
BPO	***	CNI	***
CFK	***	CP	***
GIB	***	KRY	***
FLI	***	EGO	***
CBJ	***	ENB	***
CWG	***	ERF	***
CLS	***	EENC	***
CEF	***	FHR	***
CJR	***	GRS	***
DTC	***	GSS	***
FFH	***	GBN	***
FS	***	IAG	***
GG	***	IMO	***
HBG	***	N	***
LGF	***	IDR	***
MIM	***	IPS	***
MGA	***	KFS	***
MNG	***	MFC	***
PAL	***	MRB	***
OPY	***	NCX	***
PPK	***	NXG	***
IQW	***	PMU	***
RIC	***	PTF	***
RG	***	PDG	***
SJR	***	PVX	***
TOC	***	RY	***
Widely-held Firms		SLF	***
AZK	***	SU	***
BMO	***	TU	***
BNS	***	TLM	***
BGO	***	TAC	***
BEL	***	TRP	***
CGT	***	TGA	***
HCH	***	ZL	***

Table A4.3: Test of No Information Events (Three Periods)

Significant at 10% (*), 5%(**) & 1%(***)

Family-controlled Firms				
Symbol	**α_F=0**	**α_S=0**	**α_T=0**	**α_F=α_S=α_T=0**
ABY	***	***	***	***
AGT	***	***	***	***
BVF	***	***	***	***
BPO	***	***	***	***
CFK	***	***	***	***
GIB	***	***	***	***
FLI	***	***	***	***
CBJ	***	***	***	***
CWG	***	***	***	***
CLS	***	***	***	***
CEF	***	***	***	***
CJR	***	***	***	***
DTC	***	***	***	***
FFH	***	***	***	***
FS	***	***	***	***
GG	***	***	***	***
HBG	***	***	***	***
LGF	***	***	***	***
MIM	***	***	***	***
MGA	***	***	***	***
MNG	***	***	***	***
PAL	***	***	***	***
OPY	***	***	***	***
PPK	***	***	***	***
IQW	***	***	***	***
RIC	***	***	***	***
RG	***	***	***	***
SJR	***	***	***	***
TOC	***	***	***	***
Widely-held Firms				
AZK	***	***	***	***
BMO	***	***	***	***
BNS	***	***	***	***
BGO	***	***	***	***
BEL	***	***	***	***
CGT	***	***	***	***
HCH	***	***	***	***

Widely-held Firms				
Symbol	**α_F=0**	**α_S=0**	**α_T=0**	**α_F=α_S=α_T=0**
CCJ	***	***	***	***
CNQ	***	***	***	***
CM	***	***	***	***
CNI	***	***	***	***
CP	***	***	***	***
KRY	***	***	***	***
EGO	***	***	***	***
ENB	***	***	***	***
ERF	***	***	***	***
EENC	***	***	***	***
FHR	***	***	***	***
GRS	***	***	***	***
GSS	***	***	***	***
GBN	***	***	***	***
IAG	***	***	***	***
IMO	***	***	***	***
N	***	***	***	***
IDR	***	***	***	***
IPS	***	***	***	***
KFS	***	***	***	***
MFC	***	***	***	***
MRB	***	***	***	***
NCX	***	***	***	***
NXG	***	***	***	***
PMU	***	***	***	***
PTF	***	***	***	***
PDG	***	***	***	***
PVX	***	***	***	***
RY	***	***	***	***
SLF	***	***	***	***
SU	***	***	***	***
TU	***	***	***	***
TLM	***	***	***	***
TAC	***	***	***	***
TRP	***	***	***	***
TGA	***	***	***	***
ZL	***	***	***	***

Appendix 5
Two Periods per Day Analysis of NYSE/AMEX Listed Firms

Table A5.1: PIN of Individual Family-Controlled Firms

Firm Symbol	PIN_M (Easley et al (1996b))	PIN_A (Easley et al (1996b))	Modified PIN_M	Modified PIN_A
ABY	0.145	0.160	0.100	0.120
AGT	0.160	0.166	0.094	0.093
BVF	0.112	0.112	0.082	0.081
BPO	0.176	0.171	0.141	0.133
CFK	0.203	0.233	0.099	0.124
GIB	0.145	0.148	0.083	0.079
FLI	0.172	0.186	0.101	0.099
CBJ	0.132	0.142	0.097	0.095
CWG	0.049	0.042	0.043	0.036
CLS	0.105	0.117	0.087	0.098
CEF	0.154	0.179	0.098	0.125
CJR	0.000	0.000	0.000	0.000
DTC	0.136	0.149	0.085	0.102
FFH	0.155	0.168	0.091	0.098
FS	0.146	0.126	0.101	0.091
GG	0.108	0.117	0.080	0.083
HBG	0.177	0.202	0.113	0.134
LGF	0.151	0.161	0.107	0.118
MIM	0.119	0.146	0.071	0.099
MGA	0.122	0.114	0.093	0.085
MNG	0.148	0.160	0.090	0.097
PAL	0.169	0.173	0.110	0.119
OPY	0.008	0.018	0.008	0.018
PPK	0.003	0.010	0.003	0.010
IQW	0.114	0.130	0.047	0.069
RIC	0.008	0.009	0.008	0.009
RG	0.160	0.165	0.104	0.103
SJR	0.127	0.127	0.084	0.083
TOC	0.129	0.141	0.095	0.099

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$

Table A5.2: PIN of Individual Widely-Held Firms

Firm Symbol	PIN_M (Easley et al (1996b))	PIN_A (Easley et al (1996b))	Modified PIN_M	Modified PIN_A
AZK	0.227	0.241	0.085	0.075
BMO	0.119	0.123	0.084	0.085
BNS	0.172	0.178	0.115	0.115
BGO	0.144	0.157	0.112	0.120
BEL	0.190	0.214	0.108	0.133
CGT	0.150	0.185	0.074	0.086
HCH	0.018	0.003	0.017	0.003
CCJ	0.193	0.185	0.143	0.135
CNQ	0.167	0.173	0.114	0.120
CM	0.000	0.000	0.000	0.000
CNI	0.136	0.123	0.110	0.100
CP	0.144	0.134	0.102	0.088
KRY	0.147	0.139	0.082	0.084
EGO	0.126	0.148	0.070	0.075
ENB	0.185	0.197	0.105	0.119
ERF	0.144	0.149	0.102	0.115
EENC	0.160	0.150	0.099	0.098
FHR	0.142	0.140	0.105	0.106
GRS	0.154	0.171	0.093	0.103
GSS	0.150	0.137	0.114	0.097
GBN	0.188	0.179	0.115	0.106
IAG	0.146	0.180	0.103	0.131
IMO	0.142	0.138	0.096	0.089
N	0.101	0.096	0.080	0.075
IDR	0.153	0.143	0.113	0.107
IPS	0.175	0.176	0.128	0.125
KFS	0.155	0.196	0.089	0.121
MFC	0.088	0.086	0.068	0.068
MRB	0.180	0.195	0.100	0.098
NCX	0.179	0.169	0.132	0.125
NXG	0.162	0.156	0.098	0.091
PMU	0.166	0.171	0.084	0.084
PTF	0.175	0.206	0.130	0.167
PDG	0.100	0.097	0.081	0.078
PVX	0.198	0.244	0.155	0.202
RY	0.109	0.091	0.082	0.068
SLF	0.103	0.106	0.081	0.082
SU	0.154	0.154	0.109	0.113
TU	0.238	0.224	0.158	0.139
TLM	0.158	0.169	0.118	0.125
TAC	0.136	0.167	0.077	0.079
TRP	0.143	0.152	0.097	0.110
TGA	0.168	0.183	0.110	0.126
ZL	0.171	0.172	0.091	0.099

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$

Appendix 6
Three Periods per Day Analysis of NYSE/AMEX Listed Firms

Table A6.1: PIN of Individual Family-Controlled Firms

Firm Symbol	PIN_F (Easley et al (1996b))	PIN_S (Easley et al (1996b))	PIN_T (Easley et al (1996b))	Modified PIN_F	Modified PIN_S	Modified PIN_T
ABY	0.161	0.155	0.164	0.107	0.110	0.119
AGT	0.168	0.180	0.189	0.087	0.110	0.099
BVF	0.118	0.106	0.114	0.080	0.075	0.079
BPO	0.171	0.180	0.180	0.131	0.139	0.141
CFK	0.211	0.226	0.242	0.100	0.112	0.121
GIB	0.128	0.168	0.165	0.064	0.082	0.092
FLI	0.073	0.256	0.098	0.040	0.183	0.052
CBJ	0.152	0.144	0.148	0.103	0.100	0.108
CWG	0.382	0.377	0.447	0.143	0.137	0.135
CLS	0.103	0.123	0.110	0.081	0.102	0.090
CEF	0.158	0.175	0.185	0.095	0.119	0.123
CJR	0.338	0.293	0.359	0.102	0.113	0.147
DTC	0.144	0.146	0.162	0.088	0.093	0.109
FFH	0.154	0.147	0.166	0.081	0.083	0.090
FS	0.142	0.146	0.133	0.091	0.101	0.097
GG	0.118	0.116	0.122	0.083	0.082	0.085
HBG	0.197	0.204	0.198	0.114	0.134	0.128
LGF	0.139	0.152	0.165	0.086	0.109	0.116
MIM	0.118	0.137	0.142	0.066	0.080	0.099
MGA	0.130	0.122	0.121	0.095	0.092	0.091
MNG	0.164	0.175	0.156	0.095	0.109	0.087
PAL	0.191	0.171	0.184	0.117	0.114	0.125
OPY	0.419	0.378	0.430	0.205	0.160	0.168
PPK	0.526	0.478	0.527	0.118	0.140	0.156
IQW	0.177	0.117	0.112	0.080	0.062	0.052
RIC	0.389	0.290	0.320	0.208	0.176	0.187
RG	0.177	0.151	0.183	0.115	0.092	0.111
SJR	0.146	0.122	0.126	0.098	0.076	0.079
TOC	0.129	0.149	0.150	0.089	0.106	0.104

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$

Table A6.2: PIN of Individual Widely-Held Firms

Firm Symbol	PIN_F (Easley et al (1996b))	PIN_S (Easley et al (1996b))	PIN_T (Easley et al (1996b))	Modified PIN_F	Modified PIN_S	Modified PIN_T
AZK	0.131	0.207	0.206	0.048	0.055	0.055
BMO	0.139	0.123	0.135	0.092	0.085	0.092
BNS	0.173	0.179	0.197	0.109	0.115	0.128
BGO	0.156	0.131	0.154	0.114	0.094	0.103
BEL	0.168	0.194	0.240	0.079	0.112	0.144
CGT	0.146	0.189	0.017	0.075	0.085	0.006
HCH	0.453	0.416	0.409	0.185	0.154	0.153
CCJ	0.189	0.205	0.181	0.137	0.152	0.128
CNQ	0.171	0.174	0.171	0.120	0.118	0.118
CM	0.636	0.519	0.534	0.306	0.203	0.205
CNI	0.139	0.137	0.118	0.109	0.111	0.094
CP	0.154	0.139	0.143	0.108	0.090	0.090
KRY	0.165	0.130	0.139	0.093	0.064	0.076
EGO	0.132	0.138	0.149	0.061	0.070	0.070
ENB	0.196	0.199	0.192	0.114	0.112	0.114
ERF	0.151	0.149	0.148	0.097	0.111	0.114
EENC	0.197	0.161	0.148	0.119	0.102	0.087
FHR	0.136	0.148	0.137	0.095	0.111	0.101
GRS	0.139	0.162	0.168	0.067	0.100	0.102
GSS	0.147	0.144	0.140	0.099	0.105	0.095
GBN	0.203	0.180	0.212	0.116	0.106	0.129
IAG	0.150	0.167	0.204	0.097	0.120	0.141
IMO	0.155	0.152	0.134	0.104	0.100	0.081
N	0.106	0.108	0.105	0.081	0.086	0.082
IDR	0.181	0.160	0.151	0.127	0.122	0.111
IPS	0.181	0.170	0.185	0.127	0.118	0.132
KFS	0.162	0.179	0.190	0.075	0.106	0.105
MFC	0.089	0.099	0.081	0.066	0.078	0.061
MRB	0.177	0.185	0.206	0.083	0.091	0.099
NCX	0.167	0.172	0.162	0.116	0.123	0.118
NXG	0.168	0.165	0.158	0.093	0.103	0.096
PMU	0.199	0.173	0.170	0.104	0.086	0.071
PTF	0.167	0.188	0.209	0.110	0.147	0.167
PDG	0.103	0.097	0.095	0.082	0.076	0.075
PVX	0.201	0.227	0.245	0.147	0.187	0.199
RY	0.116	0.105	0.116	0.081	0.077	0.088
SLF	0.105	0.117	0.121	0.080	0.093	0.091
SU	0.153	0.158	0.153	0.103	0.114	0.108
TU	0.235	0.228	0.221	0.148	0.151	0.131
TLM	0.164	0.165	0.165	0.122	0.122	0.118
TAC	0.207	0.090	0.285	0.113	0.060	0.109
TRP	0.145	0.155	0.144	0.099	0.106	0.102
TGA	0.175	0.179	0.198	0.105	0.119	0.136
ZL	0.192	0.181	0.167	0.095	0.105	0.089

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$

Appendix 7
Event Study of NYSE/AMEX Listed Firms

Table A7.1: Parameter Estimates around the Event Window

	Before		After		Before		After		Before		After	
Symbol	α_M	α_F	α_M	α_F	ε_M	ε_A	ε_M	ε_A	μ_M	μ_A	μ_M	μ_A
AEM	0.335	0.531	0.385	0.386	209.235	178.368	334.392	230.357	143.546	98.709	228.759	152.080
SNG	0.150	0.166	0.259	0.117	49.432	39.817	83.373	79.455	113.404	82.989	169.676	264.454
COT	0.211	0.050	0.167	0.267	71.518	90.637	167.042	134.554	85.734	192.734	224.920	131.023
GIL	0.118	0.216	0.217	0.372	82.014	76.408	124.652	96.244	164.922	104.548	198.368	108.304
GLG	0.456	0.469	0.217	0.234	324.241	233.150	316.266	242.656	219.870	150.088	238.091	221.223
MDG	0.475	0.418	0.218	0.350	273.194	233.927	208.015	176.011	143.137	119.535	192.325	125.707
MFN	0.361	0.239	0.233	0.329	23.098	23.566	19.259	15.530	32.339	37.347	26.828	22.087
POT	0.168	0.387	0.407	0.283	300.054	233.518	301.117	280.491	276.367	205.477	293.498	345.405
VGZ	0.378	0.309	0.322	0.344	30.396	22.735	23.170	17.164	46.109	32.317	45.055	31.215
Average	0.295	0.310	0.269	0.298	151.465	125.792	175.254	141.385	136.159	113.749	179.724	155.722

Appendix 8
Analysis of NASDAQ Listed Firms

Table A8.1: Two Periods per Day Analysis

Firm Symbol	PIN_M (Easley et al (1996b))	PIN_A (Easley et al (1996b))	Modified PIN_M	Modified PIN_A
		Family-Controlled Firms		
BLD	0.119	0.104	0.088	0.077
CSL	0.247	0.222	0.098	0.079
EXF	0.176	0.228	0.072	0.107
FSR	0.204	0.231	0.107	0.125
HYG	0.143	0.116	0.091	0.072
IMA	0.142	0.151	0.101	0.118
IVA	0.142	0.144	0.103	0.103
JCT	0.330	0.305	0.087	0.071
MER	0.184	0.175	0.107	0.106
NRM	0.157	0.157	0.103	0.105
RIM	0.068	0.085	0.061	0.076
STK	0.152	0.139	0.105	0.101
TES	0.148	0.173	0.078	0.099
ZIC	0.189	0.168	0.100	0.087
		Widely-Held Firms		
BIO	0.143	0.150	0.086	0.095
CSP	0.151	0.157	0.072	0.079
DRA	0.164	0.170	0.092	0.101
FMT	0.187	0.160	0.097	0.082
HUM	0.186	0.176	0.079	0.110
MEO	0.122	0.128	0.087	0.099
PAA	0.107	0.112	0.084	0.083
SSP	0.183	0.163	0.094	0.080
TLC	0.141	0.144	0.099	0.108
VSG	0.148	0.149	0.094	0.094
WED	0.184	0.212	0.086	0.103

According to Easley et al (1996b), $PIN = \alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified $PIN = \alpha\mu/(2\varepsilon + \mu)$

Table A8.2: Three Periods per Day Analysis

Firm Symbol	PIN_F (Easley et al (1996b))	PIN_S (Easley et al (1996b))	PIN_T (Easley et al (1996b))	Modified PIN_F	Modified PIN_S	Modified PIN_T
Family-Controlled Firms						
BLD	0.127	0.134	0.112	0.088	0.102	0.080
CSL	0.573	0.540	0.559	0.162	0.191	0.172
EXF	0.180	0.204	0.233	0.066	0.091	0.109
FSR	0.341	0.384	0.368	0.146	0.215	0.190
HYG	0.160	0.135	0.139	0.089	0.087	0.088
IMA	0.155	0.153	0.135	0.100	0.113	0.090
IVA	0.173	0.138	0.156	0.122	0.099	0.104
JCT	0.420	0.468	0.411	0.064	0.103	0.058
MER	0.198	0.171	0.204	0.119	0.094	0.124
NRM	0.164	0.142	0.160	0.097	0.087	0.093
RIM	0.077	0.081	0.100	0.067	0.071	0.086
STK	0.165	0.152	0.141	0.101	0.111	0.097
TES	0.168	0.155	0.169	0.082	0.087	0.091
ZIC	0.186	0.203	0.196	0.088	0.110	0.096
Widely-Held Firms						
BIO	0.167	0.151	0.156	0.092	0.091	0.089
CSP	0.180	0.134	0.201	0.080	0.062	0.106
DRA	0.165	0.183	0.176	0.072	0.116	0.103
FMT	0.194	0.179	0.171	0.091	0.095	0.081
HUM	0.421	0.371	0.378	0.140	0.180	0.193
MEO	0.134	0.129	0.126	0.090	0.095	0.089
PAA	0.118	0.114	0.121	0.091	0.088	0.089
SSP	0.185	0.183	0.155	0.085	0.088	0.070
TLC	0.148	0.142	0.138	0.097	0.097	0.092
VSG	0.161	0.162	0.153	0.097	0.106	0.093
WED	0.202	0.160	0.208	0.083	0.064	0.084

According to Easley et al (1996b), PIN = $\alpha\mu/(2\varepsilon + \alpha\mu)$ and Modified PIN = $\alpha\mu/(2\varepsilon + \mu)$